This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

LANE MEDICAL LIBRARY STANFORD
2 45 0166 8610

LANE
MEDICAL LIBRARY
SEAL OF THE LELAND STANFORD JUNIOR UNIVERSITY
1885
THE BARKAN LIBRARY OF
OPHTHALMOLOGY AND OTOLOGY

DISEASES OF THE EAR

A TEXT-BOOK
FOR PRACTITIONERS AND STUDENTS
OF MEDICINE

BY
EDWARD BRADFORD DENCH, PH. B., M. D., F. A. C. S.,
MAJOR, M. R. C.

Professor of Diseases of the Ear in the University and Bellevue Hospital Medical College; Aural Surgeon, New York Eye and Ear Infirmary; Consulting and Attending Otologist to St. Luke's Hospital; Consulting Otologist to the New York Orthopædic Dispensary and Hospital; Consulting Otologist to the New York Neurological Institute; Fellow of the American Otological Society; of the New York Academy of Medicine; of the New York Otological Society; of the New County Medical Society; of the American Medical Association, etc.

LANE LIBRARY

WITH SEVENTEEN PLATES AND ONE
HUNDRED AND SEVENTY-ONE ILLUSTRATIONS IN THE TEXT

FIFTH EDITION, REVISED AND ENLARGED

NEW YORK AND LONDON
D. APPLETON AND COMPANY
1919

Copyright, 1894, 1903, 1904, 1909, 1919
By D. APPLETON AND COMPANY

Printed in United States of America

R121
D39
1919

PREFACE TO FIFTH EDITION

IT seems hardly possible to the author that a quarter of a century has elapsed since the appearance of the first edition of this work in 1894. Perhaps in no other branch of medicine or surgery have more advances been made than in Otology. Successive editions of this work have appeared from time to time, it having been the purpose of the author, as well as of the publishers, to keep the work fully abreast with the advance of modern medicine and surgery. Since the appearance of the last edition so much advance has been made in diseases of the labyrinth, and the great importance of labyrinthine lesions has been so fully recognized that it has seemed necessary to elaborate upon this portion of the work. For this reason an entirely new chapter on the functional testing of the static labyrinth has been added. This chapter has been fully illustrated by line drawings, and it is the hope of the author that this additional chapter may be of great practical value to his readers. The chapter on specific inflammation of the labyrinth has also been practically rewritten, so as to give the readers the advantages of the latest methods of treatment.

One plate has been added, but aside from this the body of the work remains essentially the same. Lithographic plates 9, 10, and 11 have been omitted from this edition. Plate 11 was practically out of date, and plates 9 and 10, while beautiful specimens of the lithographer's art, and reflecting great credit upon my friend, Dr. W. A. Holden, who was kind enough to draw these plates from nature, do not seem to possess enough practical value to warrant their continuance in this last edition.

One new plate, which has appeared in an article by the author subsequent to the publication of the last edition, is embodied in this volume. Certain changes have been made in the text where experience has made it necessary for the author to modify opinions previously held. Certain statistics have been changed also so as to include the experience of the last ten years.

47844

The author appreciates most keenly the cordial reception which has always been accorded the previous editions of this work, and hopes that the medical profession may find this last edition as worthy of perusal as its predecessors have been.

EDWARD BRADFORD DENCH.

15 EAST 53D STREET,
NEW YORK CITY

PREFACE TO FIRST EDITION.

In the preparation of the present work it has been my aim to adapt it to the needs both of the general practitioner and the special surgeon. For this reason minute pathology has not been considered extensively.

In detailing the various manipulative procedures, I have preferred to err on the side of prolixity, for the benefit of those not familiar with the subject. It has also been my purpose to keep constantly before the reader, the fact that many diseases of the ear should not be considered by themselves, for the reason that they are often local manifestations of systemic condition.

Many works upon otology have failed to emphasize the importance of a thorough functional examination; and none have placed the results of recent investigations at the disposal of the reader in such a manner as to enable him to use them in diagnosis. In consequence, I have written at length upon this subject.

In advocating operative procedures upon the middle ear and in devoting much space to the subject of middle-ear operations, I am aware that I shall not have the support of many distinguished colleagues. As a careful reading of the chapter will show, I have written from personal experience; and if my results differ from those of other operators, I suggest that the selection of cases suitable for operation, according to the principles detailed in previous chapters, may account for the favorable outcome of the operations.

In illustrating the gross pathological lesions of the conducting mechanism and the various manipulative measures instituted for their relief, I have adopted the plan of showing the auricle, meatus, and middle ear in the same drawing. The drawings are of natural size, and the technique of the various procedures seems to be made more clear in this manner, than by any other method.

In the colored plates of the membrana tympani, the adjacent portion of the meatus is also shown, thus reproducing as completely as possible the picture seen upon speculum examination, and rendering the relative position of the parts more intelligible. In this connection I desire to express my indebtedness to Dr. W. A. Holden for the careful manner in which he prepared these plates from clinical cases. Without his aid, these illustrations would have been impossible.

The absence of extensive bibliographical citations may seem a defect, but in a work intended as a clinical guide, a complete bibliography would be impossible, and unless complete it would be useless. No attempt has been made, therefore, to collate the entire literature of any subject, and the citations have been limited to those necessary to give individual investigators the proper credit for their researches.

It gives me pleasure to thank the W. F. Ford Surgical Instrument Company for the care which they have bestowed upon the illustrations of various instruments and appliances which appear in this volume.

17 West 46th Street, New York City,

CONTENTS.

SECTION I.

THE ANATOMY AND PHYSIOLOGY OF THE EAR.

CHAPTER I.

PAGES

THE ANATOMY OF THE EAR 3-47

The auricle—The external meatus—The bony meatus—The tympanic cavity—The ossicles—The intratympanic ligaments—The membrana tympani—The epithelial investment of the conducting apparatus—Intratympanic folds—The muscles—The arteries—The veins—The lymphatics—The nerves—The bony labyrinth—The membranous labyrinth—The saccule and utricle—The membranous cochlea—The vascular supply of the labyrinth—The auditory nerve.

CHAPTER II.

THE PHYSIOLOGY OF THE EAR 48-72

Sound—Function of the membrana tympani—Function of the ossicles—Function of the muscles—Function of the cochlea and semicircular canals—Effect of tympanic changes upon the labyrinth—Effect of stimuli upon the auditory nerve—Reflex phenomena—Secondary phenomena—Hyperæsthesia and paræsthesia.

CHAPTER III.

PHYSICAL EXAMINATION 73-141

Preliminary observations—Source of illumination—The Reflecting Mirror—Specula—Technique of Examination—Appearance of the meatus and membrana tympani—Obstacles to examination—Tympanic topography—Politzerization — Catheterization—Auscultatory sounds—Obstacles to catheterization—Dangers of catheterization—The examination of the nose and throat—The history.

CHAPTER IV.

FUNCTIONAL EXAMINATION 142-170

Quantitative tests—Qualitative tests—Bone conduction—Differential diagnosis—Precautionary measures—Irregular phenomena—Special tests—Galvanic reaction of the auditory nerve.

SECTION II.

DISEASES OF THE CONDUCTING APPARATUS.

I. DISEASES OF THE AURICLE.

CHAPTER V.

PAGES

CONGENITAL MALFORMATIONS OF THE AURICLE 173–182

Deformities of particular parts of the auricle—Deformity or malposition of the entire auricle—Auricular appendages—Polyotia.

CHAPTER VI.

WOUNDS AND INJURIES OF THE AURICLE 183–186

Contused, lacerated and incised wounds—The effect of intense cold—Burns—Injuries due to the action of chemical substances.

CHAPTER VII.

CUTANEOUS DISEASES OF THE AURICLE 187–199

Intertrigo—Eczema—Pemphigus—Herpes—Syphilis—Lupus.

CHAPTER VIII.

INFLAMMATORY AFFECTIONS OF THE AURICLE 200–205

Perichondritis — Erysipelas—Abscess—Othæmatoma — Thickening of the lobule—Ossification—Gangrene.

CHAPTER IX.

BENIGN TUMORS OF THE AURICLE 206–212

Fibroma—Lipoma—Atheroma—Angioma—Cystoma—Papilloma.

CHAPTER X.

MALIGNANT TUMORS OF THE AURICLE AND OF THE MEATUS . 213–216

Epithelioma—Sarcoma.

II. DISEASES OF THE EXTERNAL AUDITORY MEATUS.

CHAPTER XI.

CIRCUMSCRIBED EXTERNAL OTITIS 217–237

ACUTE CIRCUMSCRIBED EXTERNAL OTITIS OR FURUNCLE. Ætiology—Pathology—Symptomatology—Diagnosis — Prognosis—Treatment—Bloodletting—Cold—Instillations—Heat — Incision—Internal medication. CHRONIC CIRCUMSCRIBED EXTERNAL OTITIS. Significance in diagnosis of mastoid inflammation.

CHAPTER XII.

DIFFUSE EXTERNAL OTITIS 238–266

CHRONIC DIFFUSE EXTERNAL OTITIS. Ætiology—Pathology—Superficial — Cellular — Desquamative — Parasitic—Consecutive—

PAGES

Symptomatology—Diagnosis—Prognosis—Treatment of the various varieties of the disease. ACUTE DIFFUSE EXTERNAL OTITIS. Ætiology—Dependence upon the chronic form—Pathology—Symptomatology—Diagnosis—Involvement of middle ear—Prognosis—Treatment—Local depletion—Irrigation—Cold—Incision. CROUPOUS AND DIPHTHERITIC EXTERNAL OTITIS. HÆMORRHAGIC EXTERNAL OTITIS.

CHAPTER XIII.

IMPACTED CERUMEN 267-278

Ætiology—Pathology—Symptomatology—Direct and reflex phenomena—Diagnosis—Prognosis—Treatment—Use of the syringe—Use of the curette.

CHAPTER XIV.

FOREIGN BODIES IN THE CANAL 279-284

Ætiology—Pathology—Symptomatology—Diagnosis—Prognosis—Treatment—Removal through the natural passage—Removal by external incision.

CHAPTER XV.

EXOSTOSIS OF THE EXTERNAL AUDITORY MEATUS 285-290

Ætiology—Pathology—Symptomatology—Diagnosis—Prognosis—Treatment.

CHAPTER XVI.

WOUNDS AND INJURIES OF THE MEMBRANA TYMPANI . . . 291-296

Ætiology—Pathology—Symptomatology—Diagnosis—Prognosis—Treatment.

III. DISEASES OF THE MIDDLE EAR.

CHAPTER XVII.

TUBAL CONGESTION, OR TUBAL CATARRH 304-316

Ætiology—Pathology—Symptomatology—Diagnosis—Physical examination—Functional examination—Prognosis—Treatment—Inflation—Dilatation—Medicated vapors—Prophylaxis.

CHAPTER XVIII.

TUBO-TYMPANIC CONGESTION.—TUBO-TYMPANIC CATARRH . 317-326

Ætiology—Pathology—Symptomatology—Diagnosis—Physical examination—Functional examination—Prognosis—Treatment—Inflation—Incision—Internal medication.

CHAPTER XIX.

ACUTE CATARRHAL OTITIS MEDIA 327-340

Ætiology—Pathology—Superficial structures alone affected—Symptoms in adults—Symptoms in children—Inspection of discharge—Bacteriological examination of discharge—Diagnosis—Physical examination—Functional examination—Prognosis—Treatment—Depletion—Dry heat—Instillations—Incision—Irrigation—Topical applications.

CHAPTER XX.

PAGES
ACUTE PURULENT OTITIS MEDIA 341–356

Ætiology—Pathology — Bacteriological infection—Involvement of the connective tissue in the vault of the tympanum—Secondary involvement of the lower portion of the cavity—Extension to bony structures—Symptomatology—Evidences of mastoid involvement—Evidences of extension to the cranial cavity—Diagnosis—Physical examination—Bulging of membrana flaccida—Functional examination—Prognosis—Subsequent functional condition—Chronic purulent otitis—Mastoid and intracranial involvement—Fatal cases—Treatment—Depletion—Early incision—Irrigation—Abortive treatment when mastoid symptoms appear—Ice coil and local blood-letting—Second incision unnecessary—Treatment of persistent discharge—Drainage.

CHAPTER XXI.

CHRONIC CATARRHAL OTITIS MEDIA 357–396

General considerations concerning pathological characteristics separating the cases into two classes. CHRONIC HYPERTROPHIC OTITIS MEDIA. Ætiology—Influence of repeated attacks of congestion—Unresolved acute otitis—Affections of the upper air passages—Sex—General condition—Heredity—Pathology—Tympanic changes—Changes in the drum membrane—In the Eustachian tube—In the tympanic ligaments—In the labyrinth—Symptomatology—Bilateral involvement—Intermittent character of the subjective noises and impairment of hearing—Vertigo—Reflex pain referred to the region of lingual tonsil—Diagnosis—Physical examination—Altered position and density of membrana tympani—Changes in the apparent breadth of malleus handle from rotation—Effusion—Functional examination—Impairment for voice greater relatively than for sharp sounds—Changes in the limits of audition—Condition of organ secondarily involved—Prognosis—Duration of affection—Condition of upper air passages—Degree of bilateral involvement—Age—Secondary sclerotic changes—Treatment—Treatment of the upper air passages—Surgical measures and topical applications—Of the Eustachian tube — Inflation — Irrigation — Dilatation — Electrolytic method—Topical applications—Of the middle ear—Simple inflation—Medicated vapors—Absorption or evacuation of effusion—Lavage of tympanum—Tenotomy of tensor tympani—Mechanical support in relaxation—Surgical procedures. CHRONIC HYPERPLASTIC OTITIS MEDIA. Ætiology—Secondary to acute inflammations of tympanum or to hypertrophic inflammation—Idiopathic disease resulting from systemic causes—Occurrence in one ear as the result of changes in the opposite organ—Pathology—Sclerotic changes in the tympanic connective tissue—Deposit of new connective tissue—Changes in the membrana tympani—Deposits about oval and round windows—Tension anomalies causing rotation of malleus upon its long axis—Changes in the tympanic vault—Labyrinthine involvement—Condition of the Eustachian tube—Otosclerosis—Symptomatology—Insidious development—Subjective noises without impairment of hearing—Local and reflex pain—"Auditory fatigue"—Neurasthenic manifestations — Diagnosis—Physical examination—Normal appearance of drum membrane—Atrophy of membrane—Malposition of ossicles—Appearance of membrana flaccida in cases secondary to a hypertrophic process—Functional examination—Variation in lower tone limit—Bone conduction—Lateralization of tuning fork—Determination of relative amount of tympanic and secondary labyrinthine involvement in "mixed" cases by means of tuning forks—Changes in upper tone limit and its significance—Otosclerosis—Prognosis—Spontaneous cessation of the affection—Effect of men-

PAGES

tal and physical exertion—Climatic influence—Age—Treatment—Of tympanum and tube—Passive motion—Massage—Pneumo-massage contraindicated—Vibratory massage—Surgical measures—Of labyrinth—Internal medication—Effect of treatment of middle ear upon the labyrinth—Hygienic measures.

CHAPTER XXII.

CHRONIC PURULENT OTITIS MEDIA 397–425

Ætiology—Development from an acute catarrhal or acute purulent inflammation — Tuberculosis — Syphilis — Pathology — Necrosis of connective tissue and osseous structures—Caries of incus—Cause of its frequent occurrence—Labyrinthine involvement—Cerebellar abscess—Changes in the mastoid—Cholesteatoma—Symptomatology—Discharge—Variations in the amount of discharge—Occurrence of aspergillus—Facial paralysis—Presence of granulation tissue—Secondary labyrinthine involvement—Diagnosis—Physical examination—Classification of conditions usually found upon inspection and their individual significance—Caries—Use of probe—Significance of granulation tissue—Displacement of the ossicles—Auscultatory signs—Functional examination—Variation in tone limits—Effect on upper tone limit—Bone conduction—Electrical reaction—Evidences of mastoid involvement—Prognosis—Probable effect upon audition—Cessation of discharge—Danger to life—Treatment—Use of syringe—Other methods of cleansing—Treatment of the upper air passages—Instillations—Powders—Removal of exuberant granulation tissue—Irrigation of vault of tympanum—Operative procedures—Statistics of operations—Treatment after operation—Internal medication.

CHAPTER XXIII.

OTITIS MEDIA PURULENTA RESIDUA 426–441

ACUTE TYPE. Ætiology—Identical with that of acute inflammation of the normal tympanum—Pathology—Hyperæmia of exposed lining of tympanum—Serous effusion—Becomes purulent by infection through canal—Encysted effusion—Bony necrosis with development of chronic discharge—Symptomatology—Interference with function—Discharge—Secondary external otitis—Facial paralysis—Diagnosis—Physical examination—Serous discharge—Exfoliation of superficial epithelium—Thickening of remnant of drum membrane—Signs of mastoid involvement—Prognosis—Mild cases—Severe cases with retention of pus—Treatment—Mild cases—Asepsis—Topical applications—Treatment of upper air passages—Removal of dead bone if present to prevent recurrent attacks—Severe cases—Incision of membrana flaccida with cupping—Irrigation—Cold to mastoid. CHRONIC TYPE. Condition one of increased tension—Secondary effects on labyrinth—Pathology—Classification of conditions found in these cases—Symptomatology—Interference with function—Presence of inspissated secretion—Cholesteatoma—Pain in mastoid due to sclerotic changes—Diagnosis—Necessity of combining physical conditions with data obtained by functional examination—Functional examination—Evidences of increased tension in conducting mechanism—Labyrinthine involvement—Determination of the degree to which perceptive and conducting mechanism is affected — Prognosis — Spontaneous improvement — Age—Influence of labyrinthine involvement upon the prognosis—Recent and chronic cases—Treatment—General measures—Attention to upper air passages and Eustachian tube—Prophylaxis against otomycosis—Surgical treatment—Effect of treatment upon function of opposite ear.

IV. DISEASES OF THE MASTOID PROCESS.

CHAPTER XXIV.

PAGES
The Anatomy of the Mastoid Process 442–448

Variations in presence and location of pneumatic spaces—Location of antrum—Relations between superficial landmarks and cranial contents—Topographical variations dependent upon age.

CHAPTER XXV.

Inflammation of the Mastoid Process 449–462

Ætiology—Secondary to middle-ear inflammation—Idiopathic cases—Pathology—Sclerotic changes—Caries and necrosis—Purulent inflammation—Avenues of exit of secretion—Intracranial complications and channels of infection—Possibility of infection through outer surface of squama—Cholesteatoma—Symptomatology—Pain—Temperature not characteristic—Cessation of discharge—Evidences of intracranial involvement—Evidences of extension of thrombus from sinus into internal jugular vein—Diagnosis—Local tenderness—Method of eliciting symptom—Involvement of meatus close to membrana tympani—Evidences of external rupture—Of rupture into digastric fossa—Prognosis—Importance of early recognition—Chronic cases—Influence of diathetic conditions—Gravity of operative measures—Treatment—Free drainage through canal—Cold to mastoid—Abortive treatment by ice coil—Statistics—Irrigation of canal—Objection to Wilde's incision—Early and radical operation.

CHAPTER XXVI.

Intracranial Complications of Tympanic Inflammation . 463–478

Otitic Meningitis. Manner in which inflammation extends to meninges—Serous meningitis—Symptomatology—Variations dependent upon location of lesion—Ocular symptoms—Symptoms of serous meningitis—Diagnosis—Temperature—Headache—Vomiting—Choked disk—Prognosis—Advisability of operative interference—Treatment—Cold applications—Internal medication—Surgical treatment. Sinus Thrombosis. Avenues of infection—Extension to internal jugular—Secondary deposits—Symptomatology—Rigors and sweating—Intermittent temperature—General sepsis—Evidences of secondary deposits—Diagnosis—Value of frequent thermometric observations—Meningitis—Extension of thrombus—Involvement of lymphatics—Examination for choked disk—General condition of patient—Prognosis—Apparent recovery—Statistics of results of operative treatment—Extension to internal jugular—Statistics—Latent cerebral deposits—Treatment—Operative treatment—Medication—Alimentation. Extradural Abscess. Nature of the process—Symptomatology—Localized headache—Temperature changes—Mental condition—Prognosis—Latent deposits—Spontaneous evacuation—Value of operative treatment—Treatment—Necessity of surgical interference. Cerebral Abscess. Origin—Site—Latent deposits—Symptomatology—Dependent upon location—Aphasia and agraphia—Constitutional symptoms—Asthenia—Sleeplessness—Temperature—Diagnosis—General asthenic symptoms—Sleeplessness—Low temperature—Difficulties in Diagnosis due to complicating lesions—Prognosis—Natural progress when not interfered with—Proper time for surgical interference—Results of operative treatment—Treatment—Evacuation by operation. Cerebellar Abscess. Frequency—Pathological changes—Symptomatology—Vomiting—Dizziness and unsteadiness in gait—Dullness and apathy—Headache—Temperature—Diagnosis—Difficult because of absence of pathognomonic symptoms—Choked disk may be present—Symptoms may be those of serous meningitis—Prognosis—Chances of recovery if recognized in time—Treatment—Evacuation by operation.

SECTION III.

SURGERY OF THE CONDUCTING APPARATUS.

CHAPTER XXVII.

MIDDLE-EAR OPERATIONS 481–531

PRELIMINARY PREPARATIONS. Instruments—Form—Construction—Sterilization—Field of operation—Necessity of asepsis—Method of securing an aseptic condition of the parts—Anæsthesia—Limitations of local anæsthesia—Conditions demanding general anæsthesia—Position of the patient—Advantages of elevation of head and shoulders. CLASSIFICATION OF OPERATIONS. I. Operations upon the Membrana Tympani—Myringotomy for evacuation of fluid—For depletion—For exploration—Partial myringectomy—Multiple incisions—Plicotomy. II. Operations involving Section of Intra-tympanic Tissues—Tenotomy of the tensor tympani—Methods of operating—Division of the anterior ligament of the malleus—Division of adhesions in suppurative and nonsuppurative cases. III. Operations involving the Ossicular Chain—Excision of a portion of the manubrium—Disarticulation and mobilization of the stapes—Plastic operations—Removal of the ossicles—Technique when the membrana tympani is intact—Treatment after operation—Reaction following operation—Reproduction of the membrana tympani—Technique when membrane is partially destroyed—Hæmorrhage during operation—Difficulty of securing the remnant of the incus—Curetting of tympanum after removal of ossicles—Subsequent treatment—Details of technique of disarticulation at the incudo-stapedial joint and removal of the incus—Frequency of caries of incus—Control of hæmorrhage—Possible accidents—Stacke's operation—Author's operation—Statistics—Stapedectomy—With intact drum membrane—With drum membrane partially destroyed—Statistics of author's operations showing the effect upon the function of audition in cases operated upon.

CHAPTER XXVIII.

THE MASTOID OPERATION 532–545

Instruments—Preparation of field of operation—Incision—Separation of sterno-mastoid muscle—Removal of cortex—Removal of softened bone—Accidents during operation—Opening of lateral sinus—Treatment—Laceration of dura—Treatment—Dressing—After-treatment—Technique of operation in young children—Technique in mastoid sclerosis—Destruction of osseous tissue—Trautmann's operation for closure of opening—Mosetig-Moorhof's method—Paraffin treatment reported by Frey—Technique of injection.

CHAPTER XXIX.

RADICAL OPERATION FOR CHRONIC OTORRHŒA — STACKE-SCHWARTZE OPERATION 546–563

Necessity for free drainage—Combination of the methods of Küster, Bergmann, and Stacke to form Stacke-Schwartze operation—Technique—Situation of incision varies with operators—Structures to be avoided in operating—Lining of cavity with flaps—Panse's modification—Koerner's modification—Jansen's modification—Ballance's

PAGES

method—Author's method—Tiersch grafting—Irrigation of wound at first dressing—Dressing—Results of operation—Author's statistics—Secondary operation—Accidents during operation—Injury of facial nerve—Exposure of dura—Exposure of lateral sinus—Treatment after accidents—Perichondritis of auricle.

SECTION IV.

THE SURGICAL TREATMENT OF INTRACRANIAL COMPLICATIONS OF AURAL SUPPURATION.

INTRODUCTORY REMARKS 569–570

Necessity for operation—Hesitation justified in extensive meningitis—Wisdom of making an ample opening—Displacement of a semicircular flap.

CHAPTER XXX.

SINUS THROMBOSIS 571–578

Perforation of skull—Necessity for asepsis—Care in use of rongeur forceps—Signs of normal sinus—Exploratory puncture valueless—Site for incision—Signs of clot—Relative importance of hæmorrhage from above and from below—Breaking down of clot—Symptoms of extension of thrombus into internal jugular—Excision of infected vein—Technique of operation—Not advisable to wash out clot by injection of fluid into proximal extremity of vein—Dressing—Statistics of results.

CHAPTER XXXI.

OTITIC MENINGITIS 579–585

Exploratory craniotomy—Relief of intracranial tension—Incision for evacuation of fluid in lateral ventricles—Technique—Lumbar puncture—Method of performing puncture—Necessity for asepsis—Value as a diagnostic measure—Normal pressure of spinal fluid—Increase of pressure in meningitis—Lumbar puncture of no value as a therapeutic measure—Epidural abscess—Usual location—Operation—Irrigation of abscess cavity.

CHAPTER XXXII.

CEREBRAL AND CEREBELLAR ABSCESS 586–594

Symptoms of cerebral abscess obscure—Location of abscess—Puncture—Operation and evacuation of pus—Danger of inserting instrument into cerebral substance—Disadvantage of irrigation at time of primary operation—Packing of abscess cavity with gauze—Whiting's encephaloscope—After-treatment of wound—Method of dressing varies with different authorities—Drainage tube advisable—Precautions to avoid retention of pus, and the protrusion of brain substance—Evacuation of lateral ventricle if entered during exploratory incision—Cerebellar abscess—Exploratory incision—Evacuation of pus—Cleansing of cavity with gauze or cotton mops—Dressing of wound.

SECTION V.

DISEASES OF THE PERCEPTIVE MECHANISM.

INTRODUCTORY REMARKS 597–600

Character of auditory impairment—Comparative value of physical and functional examination—Importance of complete history—Location of the pathological process.

CHAPTER XXXIII.

PAGES
THE EXAMINATION OF THE STATIC LABYRINTH 601–618

The semi-circular canals—Methods of illustrating each canal system for purposes of demonstration—Anatomy of vestibular branch of auditory nerve—Definite muscular movements elicited by vestibular stimulation—Experiments of Hoyges, Von Stein, Neumann and Barany—Nystagmus—Vestibular component of nystagmus—Variations in voluntary body movements resulting from stimulation of semi-circular canals—Overpointing—Rotation as a means of determining lesions of the end organ of vestibular nerve, lesions of nerve trunk, and of communicating fibers within brain—Apparatus for experiments in rotation—Technique—Stimulation of the superior semi-circular canal system—Symptoms of diseased labyrinth—Barany's method of determining dead labyrinth by use of caloric test—Irritability of labyrinth to caloric stimulation—Double caloric test for determining relative irritability of each labyrinth—Galvanic reaction test—Diagnosis of tumors of the cerebello-pontine angle involving the eighth nerve—Tumors of eighth nerve in the porus acousticus internus—Reversal of direction of nystagmus in cerebellar abscess.

CHAPTER XXXIV.

ANÆMIA OF THE LABYRINTH 619–621

Ætiology—Profuse hæmorrhage—Constitutional conditions—Symptomatology—Functional impairment—Subjective noises—Disturbances of static function—Diagnosis—Physical examination—Functional examination—Tone limits often preserved or upper tone limit may be lowered—Deficient bone conduction—General anæmia—Prognosis—Dependent upon cause—Treatment—Stimulants—Tonics—Drugs to be avoided

CHAPTER XXXV.

HYPERÆMIA OF THE LABYRINTH 622–625

Ætiology — General condition — Occupation—Concussion—Acute or chronic venous engorgement—Pathology—Dilatation of veins—Extravasation—Serous transudation—Symptomatology—Variations in degree and persistence of the manifestations—Diagnosis—Absence of definite physical signs—Functional examination—Preservation of lower tone limit—Upper tone limit reduced—Impairment of bone conduction—Prognosis—Varies with duration and degree of process—Treatment—Acute cases—Depletion—Rest—Occlusion of canal—Pilocarpine—Chronic cases—Counter-irritation—Pilocarpine and the method of its administration—General hygienic rules.

CHAPTER XXXVI.

LABYRINTHINE HÆMORRHAGE 626–628

Ætiology—Concussion—Direct traumatism—Blood conditions—Changes in the walls of the blood vessels—Diatheses—Pathology—Extravasation—Subsequent changes—Symptomatology—Prodromata—Sudden access of symptoms—Symptoms usually severe—Gradual abatement of manifestations—Recurrence—Diagnosis—Value of clinical history—Functional examination—Absence of bone conduction—Absolute deafness or great auditory impairment—Upper tone limit reduced—Occasional disturbances of lower tone limit—Prognosis—Varies with the severity of hæmorrhage—Static function usually restored—

PAGES

—Treatment—Acute stage—Depletion—Rest—Revulsives—Chronic stage—Reduction of labyrinthine pressure—Prophylaxis.

CHAPTER XXXVII.

LABYRINTHINE EMBOLISM AND THROMBOSIS 629–630

Ætiology—Metastasis—Inflammation of contiguous structures—Pathology—Results in local anæmia—Local necrosis—Inflammation—Symptomatology—Function of organ usually not much disturbed—Spontaneous improvement—Prognosis—Condition not progressive—Treatment—Removal of cause—Reduction of labyrinthine pressure—Relief of subjective symptoms—Stimulation of impoverished nerve tissue.

CHAPTER XXXVIII.

SPECIFIC INFLAMMATION OF THE LABYRINTH 631–634

Ætiology—Hereditary or acquired syphilis—Pathology—Chronic inflammatory changes—Hypertrophy—Changes in walls of vessels—Necrosis—Symptomatology—Sudden access in acquired form—Invasion less sudden in hereditary cases—Diagnosis—Physical examination—Recognition of concomitant tympanic disease—Functional examination—Deficient bone conduction—Lowering of upper tone limit—Differential diagnosis in "mixed" form—"Hutchinson teeth"—Examination by the Wassermann or Noguchi methods—Prognosis—Influence of heredity—Age of local process—Spontaneous quiescence—Treatment—Antisyphilitic medication—Salvarsan—Pilocarpine—Iodide of potassium—Strychnine in advanced cases—Tonic treatment in hereditary cases.

CHAPTER XXXIX.

INFLAMMATION OF THE LABYRINTH SECONDARY TO CHRONIC SUPPURATIVE AND NONSUPPURATIVE INFLAMMATION OF THE TYMPANUM 635–645

Pathology—Inflammatory changes—Atrophic changes—Extension of inflammation from tympanum—Condition of oval and round window—Results of suppuration—Functional disturbances—Symptomatology—Subjective noises—Significance of disappearance of tinnitus—Vertigo—Sympathetic involvement of opposite ear—Diagnosis—Physical examination—Absence of physical signs in certain cases—Value of inspection in residual purulent cases—Functional examination—Evidences of obstruction to sound conduction—Necessity of repeated examinations—Determination of relative importance of tympanic and labyrinthine lesion—Electrical tests—Importance of examination upon both sides to determine secondary involvement of apparently healthy organ—Prognosis—Residual purulent cases usually progress but slowly or not at all—Dangers of sympathetic involvement—Treatment—Relief of cause in middle ear—Preservation of organ involved secondarily—Special measures directed toward labyrinth—Pilocarpine—Strychnine—Specific treatment—Persistent stimulation by sonorous vibrations—Relief of subjective noises—Treatment of the upper air passages—Danger of treating middle ear in advanced cases.

CHAPTER XL.

ACUTE INFLAMMATION OF THE LABYRINTH SECONDARY TO ACUTE OR CHRONIC PURULENT OTITIS MEDIA 646–653

Ætiology—Ordinary causes of acute purulent otitis media—Virulence of process—Pathology—Tissue necrosis—Avenues of

infection—Infection of cranial contents—Obliteration of labyrinth from deposit of new tissue—Symptomatology—Not characteristic in young subjects—Evidences of labyrinthine infection in adults—Importance of facial paralysis as a symptom—Disturbance of static function—Retrogression of symptoms—Hæmorrhage—Permanent impairment of audition—Diagnosis—Physical examination—Not characteristic of labyrinthine involvement—Evidences of caries of internal tympanic wall—Functional examination in children unsatisfactory—In adults—Upper tone limit much lowered—Bone conduction absent or greatly reduced—Vertigo—Prognosis—Unfavorable for complete restoration of function—Often fatal in children—In adults not as great a menace to life—Danger of absolute deafness less common in adults—Danger of causing deaf-mutism in children—Treatment—Prophylaxis against infection by asepsis from the first—Relief of tinnitus—Procedures to combat extension to meninges—Cold locally—Purgation—Value of pilocarpine after acute stage has been passed.

CHAPTER XLI.

INVOLVEMENT OF THE PERCEPTIVE MECHANISM IN THE ACUTE INFECTIOUS DISEASES 654–660

Introductory remarks—Direct infection of labyrinth—Concomitant middle-ear inflammation—Pathology—Inflammatory changes—Increase of tension by effusion—Occlusion of vestibular and cochlear aqueducts—Symptomatology—Impairment of function—Tinnitus—Influence of age of patient upon manifestations—Resultant mutism in children—Diagnosis—Simple if middle ear is normal—Determination of labyrinthine lesion if tympanum is also affected—Value of functional examination in differential diagnosis—"Tone gaps"—Prognosis—Not grave in recent cases—More amenable to treatment in children than in adults—Treatment—Reduction of labyrinthine pressure by pilocarpine—Strychnine in chronic cases—Value of persistent education of power of audition. EFFECT OF CERTAIN PARTICULAR DISEASES OF THIS CLASS. MUMPS. Metastatic infection of labyrinth—Prognosis excellent in cases subjected to medication at an early period. TYPHUS AND TYPHOID FEVER. Probably causes changes in cortical centres—Usually disappear during convalescence. EPIDEMIC INFLUENZA; DIPHTHERIA. Probable involvement of nerve trunk—Impairment in audition for middle portion of musical scale—Tone limits unchanged—Galvanic hyperæsthesia—Bone conduction not lost, but reduced—Treatment directed toward improving general condition—Value of strychnine after acute stage. EPIDEMIC CEREBRO-SPINAL MENINGITIS. Pathology—Extension to labyrinth through aqueducts—Inflammatory changes—Extravasation—Deposit of new tissue—Secondary invasion of tympanum—Symptomatology—Vertigo—Severe tinnitus—Hyperacusis—Paralytic symptoms—Diagnosis—Physical examination—Negative unless tympanum is secondarily involved—Functional examination—Profound impairment of audition—Upper tone limit greatly reduced as a rule—Exceptions—Effect of hyperæsthesia on the perception of low notes—Bone conduction almost or entirely wanting—Prognosis—Complete deafness in severe cases—Significance of disappearance of tinnitus—Danger of mutism in children—Treatment—Prophylaxis impossible—Local depletion and catharsis in early stages—Pilocarpine valuable after acute stage—Cases of long standing—Strychnine—Value of systematic exercise of auditory function by the use of conversation tube, etc.

CHAPTER XLII.

PAGES
INVOLVEMENT OF THE PERCEPTIVE MECHANISM IN ACUTE MENINGITIS 661–665

Pathology—Labyrinthine lesion—Involvement of nerve trunk—Cortical lesions—Symptomatology—Variations due to location of lesion—In the labyrinth—Subjective noises—Vertigo—Impaired audition—Affecting nerve trunk—Interference with perception of middle notes of musical scale—Limits of audition normal—Significance of unilateral impairment—Cortical lesion—Bilateral impairment—Word deafness—Later symptoms—Diagnosis—Physical examination—Negative frequently—Importance of rupture of membrane in traumatic cases—Functional examination—Characteristics of labyrinthine lesion—Of lesions of nerve trunk—Of cortical involvement—Value of electrical tests—Prognosis—Treatment—Acute stages—Pilocarpine in later stages—Iodide of potassium—Strychnine—Exercise of auditory function.

CHAPTER XLIII.

THE EFFECT OF DISEASES OF THE GENERAL NERVOUS SYSTEM UPON THE PERCEPTIVE MECHANISM 666–668

CORTICAL LESIONS. Bilateral involvement—Word deafness—Auditory hallucinations—Intermittent tinnitus. TABES DORSALIS. Degeneration of nerve trunk—Galvanic hyperæsthesia—Perception of middle notes impaired—Torpidity of nerve in later stages. LESIONS OF VESTIBULAR NERVE AND OF CEREBELLUM. Disturbance of equilibrium—Diagnosis—Dependent upon general rather than special symptoms—Treatment—Value of bromides—Strychnine—Antisyphilitic medication.

SECTION VI.

COMPLICATING AURAL AFFECTIONS.

CHAPTER XLIV.

AURAL AFFECTIONS COMPLICATING THE ACUTE INFECTIOUS DISEASES . 671–673

Affection of perceptive apparatus—Involvement of conducting mechanism—Character determined by degree of infection—Portions of tympanum involved—Extension to other regions.

CHAPTER XLV.

AURAL AFFECTIONS DEPENDENT UPON CHRONIC VISCERAL CONDITIONS 674–681

Symptoms due chiefly to circulatory changes. NEPHRITIS. Effect due to venous obstruction—Arterial sclerosis and impoverished quality of blood—Tympanic effusion—Extravasations—Labyrinthine hæmorrhage—Hæmorrhage into nerve sheath. METASTASIS. Embolism of labyrinthine vessels from remote suppurative process—Infection of middle ear. TUBERCULOSIS. Tympanic involvement—Absence of pain—Multiple perforation—Constitutional treatment—Effect of tympanic process upon general condition. LEUCÆMIA. Extravasation into labyrinth—Deposit of new tissue—Sudden appearance of symptoms—Diagnostic data. DIABETES. Frequency of inflammation in external meatus—As predisposing cause of middle-ear suppuration—Extravasations in labyrinth, nerve trunk, or centres. GOUT AND RHEUMATISM. Cutaneous manifestations in canal—Arthritic inflammation in middle ear—Changes in the blood vessels and the results. MEDICINAL SUBSTANCES. Quinine—Effect on middle ear and labyrinth—Salicin and salicylic acid—Conditions contraindicating their administration—Tobacco—Effect upon higher centres.

CHAPTER XLVI.

PAGES

DISTURBANCES OF AUDITION DEPENDENT UPON FUNCTIONAL NERVOUS DISORDERS 682–687

Unimportant physical changes as a cause of manifestations in a particular region—Perversion or impairment of function with no evident lesion. NEURASTHENIA. "Auditory strain"—Psychological effect—Character of impairment of hearing—General sensory paræsthesiæ—Diagnosis—Physical examination often negative—Functional examination—Perception of high and low notes—Reduction of bone conduction—Variable results obtained by successive tests—Recognition of general neurotic condition—Hyperacusis—Auditory fatigue—Prognosis—Influence of organic changes in ear—Influence of general neurosis—Treatment—Strychnine—Bromides—Rest—Change of habit of life. HYSTERIA. Degree of impairment—Sudden appearance—Subsequent course—Associated hysterical paralyses—Transference—Absence of subjective noises—Diagnosis—Sudden onset—Absence of physical changes—Cutaneous anæsthesia—Functional examination—Contraction of range of audition—Upper tone limit most affected—Alternate variations in upper limit—Contraction of field of vision—Prognosis—Treatment—Attention to general neurosis—Hypnotic treatment.

CHAPTER XLVII.

REFLEX AURAL DISTURBANCES 688–693

Vaso-motor changes—Trophic disturbances. EXTERNAL MEATUS. Reflex inflammation—Cutaneous hyperæsthesia—Hæmorrhage. MIDDLE-EAR. Reflex otitis media—Otalgia—Angioneurotic œdema of mastoid. PERCEPTIVE MECHANISM. Paræsthesia—Influence of visceral disorders—Interference with static function—Irregularity and transitory character of symptoms—Absence of local cause—Presence of remote lesion—Effect of one ear upon opposite organ—Physiological interdependence—Pathological correlation—Value of electrical hyperæsthesia in diagnosis—Prognosis—Duration of reflex symptoms—Nature of exciting cause—Treatment—Early administration of bromides—Removal of exciting cause—Antispasmodics—Opium contraindicated—Tonic treatment.

CHAPTER XLVIII.

DEAF-MUTISM 694–699

Definition—Varieties—Ætiology. CONGENITAL FORM. Heredity—Consanguinity—Nationality—Social condition—Defective mental development—Specific disease—Causes operative during intra-uterine life. ACQUIRED FORM. Traumatism—Infectious diseases—Intracranial disease—Middle-ear inflammation—Adenoid vegetations and the resultant tympanic condition—Cause of mutism in acquired form—Pathology—Congenital malformation of conducting or perceptive mechanism—Obstructive lesions of canal or tympanum from a pathological process—Pathological conditions in the perceptive mechanism—Secondary atrophic changes—Symptomatology—Mutism in young children—In older children auditory impairment first noticed—Diagnosis—Difficulties in very young children—Importance of complete history—Importance of thorough functional examination with a series of musical tones—Prognosis—Congenital cases—Acquired cases—Possible errors—Treatment—Elimination of possible causes present—Removal of adenoid vegetations—Internal medication—Necessity of early diagnosis—Early systematic instruction in cases not amenable to treatment.

PAGES

DISEASES OF THE NOSE AND NASO-PHARYNX.

Classification of pathological conditions—Manner in which various local lesions affect sense of hearing.

CHAPTER XLIX.

HYPERTROPHIC RHINITIS.—DEFORMITIES OF THE NASAL SEPTUM . 700–705

HYPERTROPHIC RHINITIS. Nature of tissue changes—Resultant conditions—Symptoms referable to upper air passages—Aural symptoms—Referable to middle ear—Influence upon labyrinth—Relief of labyrinthine symptoms from intranasal treatment—Speculum examination—Evidences of hypertrophy—Changes following the use of cocaine—Effect of treatment—Technique of local application—Surgical treatment. DEFORMITIES OF THE NASAL SEPTUM. Method of removal with saw—Preparation of instruments—Dressing—Use of galvano-cautery.

CHAPTER L.

ATROPHIC RHINITIS 706–708

Pathological changes in membrane—Conditions resulting from the atrophic process—Insignificance of aural symptoms—Relation between aural and nasal conditions—Treatment—Irrigation—Precautions in using nasal douche—Results of intranasal treatment upon the aural symptoms—Sprays—Local stimulation.

CHAPTER LI.

ADENOID VEGETATIONS 709–712

Importance of condition—Diathetic nature of affection—Symptoms referable to upper air tract—Aural symptoms—Otalgia—Discharge—Impairment of function—"Inattention" as a symptom—Condition of oro-pharynx—Posterior rhinoscopy—Recognition by anterior rhinoscopy—Digital exploration—Technique of removal with forceps and curette—Possible sequelæ to operation—Enlarged faucial tonsils—Effect upon audition—Methods of removal in children and adults.

CHAPTER LII.

NASO-PHARYNGEAL CATARRH 713–714

Atrophic nature of process—Symptoms referable to vault of pharynx—Changes in ear concomitant rather than resultant—Aggravation of aural condition by changes in naso-pharynx—Effect upon audition of treatment of naso-pharynx—Topical applications in acute conditions—Topical applications in chronic conditions.

CHAPTER LIII.

ARTIFICIAL AIDS TO HEARING 715–716

Ear trumpet—Modifications of—Cane—Fan—Lorgnette—Telephone instrument.

LIST OF ILLUSTRATIONS.

PLATES.

PLATE		FACING PAGE
I.	—Anatomical Plate: (*A*) View of Tympanic Ring with Wall of Middle Ear and Ossicles; (*B*) Semicircular Canals and Facial Canal	14
II.	—Anatomical Plate: (*A*) Section through Middle Ear; (*B*) Section through Temporal Bone, showing Mastoid, Facial Canal, and Internal Wall of Middle Ear	15
III.	—The Arterial Supply of the Conducting Apparatus	28
IV.	—The Venous Supply of the Conducting Apparatus	30
V.	—The Vascular Supply of the Cochlea	31
VI.	—The Auditory Nerve	45
VII.	—Bezold Continuous Tone Series	150
VIII.	—Bezold Continuous Tone Series	150
IX.	—The Complete Mastoid Operation	532
X.	—Instruments for Mastoid Operation	534
XI.	—Instruments for Radical Operation	546
XII.	—The Completed Radical Operation	552
XIII.	—Cranio-cerebral Topography. (Chipault.)	568
XIV.	—Exploration of Middle Cranial Fossa. Lateral Sinus and Cerebellum. Ligation of Internal Jugular	571
XV.	—Dissection of Internal Jugular Vein, showing Free Venous Anastomosis as Contrasted with Plate XIV	575
XVI.	—Operation for Suppurative Inflammation of the Labyrinth	652
XVII.	—Neumann's Operation for Suppurative Inflammation of the Labyrinth	654

ILLUSTRATIONS IN THE TEXT.

FIGURE		PAGE
1.	The cartilaginous framework of the auricle	4
2.	The auricle	5
3.	The cartilaginous meatus	6
4.	The incisures of Santorini	7
5.	The development of the temporal bone	8
6.	Temporal bone of infant	9
7.	The adult temporal bone	10
8.	The external meatus and membrana tympani of a child at birth	10

FIGURE PAGE
9. External meatus, membrana tympani, and middle ear from a child five years old 11
10. Sagittal section through external auditory meatus, membrana tympani, and middle ear of an adult 11
11. The internal tympanic wall 12
12. The internal tympanic wall and the vault of the tympanum, with ossicles *in situ* 14
13. The ossicles and the annulus tympanicus 15
14. The malleus, incus, and stapes in various positions 16
15. The tympanum from above 18
16. Section through mastoid, tympanum, and Eustachian tube. . . 19
17. Transverse section of Eustachian tube 20
18. The pockets of the membrana tympani 24
19. The malleo-incudal articulation covered by the superior malleo-incudal fold 24
20. The nerves of the conducting mechanism and their anastomotic branches 32
21. The nerve distribution within the tympanum 33
22. The bony labyrinth 34
23. The membranous labyrinth 38
24. Vertical section of the membranous cochlea 42
25. Pen drawing from adult specimen, showing result of drawing auricle upward and backward 73
26. Drawing from specimen at birth 74
27. Drawing from specimen from child aged five years 74
28. Author's portable illuminating apparatus 77
29. Hand mirror 79
30. Reflecting mirror adapted for hand or head 80
31. Head mirror with nasal support 81
32. Head mirror. 81
33. Electric lamp worn upon the forehead. 82
34. Politzer's hard-rubber aural speculum 84
35. Wilde's aural speculum 84
36. Gruber's aural speculum 85
37. Toynbee's aural specula 85
38. The ocular inspection of the membrana tympani. 87
39. The normal membrana tympani 91
40. Middle-ear probe 99
41. Cotton holder 100
42. Siegle's pneumatic speculum 101
43. Auscultation tube 103
44. Politzer's air bag 104
45. The Eustachian catheter 107
46. Introduction of the Eustachian catheter (first step) 111
47. Introduction of the Eustachian catheter (second step) . . . 111
48. Introduction of the Eustachian catheter (the instrument in the mouth of the tube) 112
49. Vertical section through nasal chambers and pharyngeal vault of adult. 119

FIGURE PAGE
50. The same in a child of five years 120
51. Section through nasal passages and naso-pharynx in an infant . 121
52. Noyes's Eustachian catheter 124
53. Pomeroy's faucial catheter 125
54. Bosworth's nasal speculum 135
55. Bosworth's tongue depressor 137
56. Folding tongue depressor 137
57. Türck's tongue depressor 137
58. Rhinoscopic mirror 138
59. Politzer's acoumeter 143
60. Urbantschitsch's electric acoumeter 146
61. The author's tuning fork 148
62. The author's modification of the Galton whistle 156
63. Blake's tuning fork 157
64. Hartmann's series of tuning forks 158
64*a*. Congenital asymmetry and deformity of auricle 172
65. Anomalous division of the antihelix 175
66. Microtia 176
67. Auricular appendage 179
68. Fistula congenita auris 179
69. Polyotia 180
70. Aural ice bag 185
71. Deformity following perichondritis 200
72. Othæmatoma 202
73. Soft fibroma filling the concha 206
73*a*. Fibroma of lobule 206
74. Atheroma 208
75. Sebaceous tumor of the lobule 208
76. Cystoma of auricle 211
76*a*. Horny growth from lobule 212
77. Otitis externa acuta circumscripta 222
78. Otitis externa acuta of deep portion of meatus 223
79. Bacon's scarificator 227
80. Author's artificial leech 228
81. The Leiter coil 229
82. Hard-rubber ear syringe 234
83. Development of a fungus 241
84. Microscopic characteristics of otomycosis 242
85. Otomycosis 246
86. Aspergillus flavus 247
87. Appearance in infancy due to escape of fluid from tympanum through Rivinian fissure 249
88. Acute diffuse external otitis 257
89. Crust on supero-posterior wall of canal covering perforation in membrana tympani 272
90. Method of removing cerumen with the curette 276
91. Linear rupture of the membrana tympani 293
92. Retraction of the membrana tympani 307

FIGURE PAGE
93. Author's bougie catheter for the Eustachian tube 313
94. Author's middle-ear vaporizer 315
95. Moderate retraction of membrana tympani; incudo-stapedial articulation visible. 321
96. Bulging of the posterior segment of the membrana tympani . . 321
97. Method of incising the membrana tympani 325
98. Moderate bulging of the entire membrana tympani 333
99. Blake's middle-ear syringe. 339
100. Acute purulent otitis media; bulging of membrana flaccida . . 346
101. Acute purulent otitis media; fluid confined in the pockets of the membrane 347
102. Chronic catarrhal otitis media; rotation of malleus upon its long axis 364
103. Chronic catarrhal otitis media; supernumerary posterior fold . . 365
104. Chronic catarrhal otitis media; moderately retracted membrane . 385
105. Delstanche's masseur. 389
106. Chronic purulent otitis media; extensive destruction of membrana vibrans. 405
107. Chronic purulent otitis media; exuberant granulations in tympanum. 405
108. Chronic purulent otitis media; margin of perforation partially adherent 405
109. Chronic purulent otitis media; perforation in membrana flaccida . 406
110. Chronic purulent otitis media; displacement of ossicles . . . 406
111. Chronic purulent otitis media; small perforation in posterior quadrant 406
112. Removal of an aural polyp with the snare. 416
113. Removal of an aural polyp with the sharp curette 417
114. Irrigation of the tympanic vault. 420
115. Inspissated secretion covering a small perforation in the membrane . 434
116. The pneumatic mastoid 442
117. The diploïc mastoid 443
118. Horizontal section through mastoid, showing the position of the sigmoid groove. 444
119. Section through mastoid, showing the relative position of the lateral sinus and the antrum 444
120. Section through mastoid, showing the sinus in an anomalous position 445
121. Anomalous development of the temporal ridge 447
122. The tympanic vault and mastoid antrum at birth 448
123. Instruments for middle-ear operations 482
124. Author's head and shoulder rest 485
125. Lance-shaped myringotome 486
126. Method of incising the membrana flaccida for depletion . . . 488
127. Exploratory myringotomy 489
128. Author's scissors for middle-ear operations 491
129. Hartmann's tenotome 493
130. Tenotomy of the tensor tympani 494
131. Tenotomy of the tensor tympani 494

FIGURE PAGE
132. Tenotomy of the tensor tympani 495
133. Division of tympanic adhesions 497
134. Division of adhesions behind the stapes 499
135. Disarticulation at the incudo-stapedial joint 499
136. Exposure of the incudo-stapedial joint 503
137. McKay's ear forceps 505
138. Incus hook in position 507
139. Author's chisel forceps 509
140. Incus partially destroyed by caries 523
141. Trautmann's plastic operation for closure of opening behind the ear . 541
142. Same operation, showing manner of passing sutures . . . 541
143. Trautmann's operation, showing deep sutures tied, and superficial wound closed with interrupted sutures 542
144. Mosetig-Moorhof's operation for closure of retro-angular fistula . 543
145. Exposure of tympanic vault and its contents 550
146. Appearance of bony cavity after the complete radical operation . 551
147. Complete Stacke-Schwartze operation 552
148. Stacke-Schwartze operation. Formation of flaps by Panse's method. 553
149. Stacke-Schwartze operation. Formation of flap by Kõrner's method. 553
150. Incision of concha to form conchal flap. Ballance's method . . 554
151. Conchal flap sutured in position. Ballance's method . . . 554
152. Passow's method of lining the operation wound by a skin flap taken from the neck 555
153. Formation of flaps for lining the bony cavity after radical operation. Method of Jansen and Forselles 556
154. Method of Schwartze and Kretschmann of lining bony cavity with skin flaps 556
155. Ballance's instruments for skin grafting 558
156. Lateral aspect of skull showing Reede's base line 566
157. Whiting's encephaloscope 590
158. Position of arms illustrating the horizontal semi-circular canal system 602
159. Position of arms illustrating superior semi-circular canal system . 602
160. Position of hands representing the three semi-circular canals of the left side 603
161. Diagram illustrating the resulting nystagmus upon rotation of the patient to the right, the head being held so as to bring the horizontal canals into the plane of rotation 606
162. Diagram illustrating the resulting nystagmus upon rotation of the patient to the left, the head being held so as to bring the horizontal canals into the plane of rotation 607
163. Diagram illustrating the resulting nystagmus upon rotation of the patient to the right, the head being inclined 60 degrees forward so as to bring the superior semi-circular canals into the plane of rotation 609
164. Diagram illustrating the resulting nystagmus upon rotation of the patient to the right, the head being bent backward so as to bring the superior semi-circular canals into the plane of rotation . . 610
165. Diagram illustrating spontaneous nystagmus when the left labyrinth is dead 611
166. Diagram illustrating the upward current produced in fluid when the outside of the vessel is heated 612

FIGURE PAGE

167. Diagram illustrating the downward current produced in fluid when the outside of the vessel is cooled 612
168. Diagram illustrating the nystagmus produced when the left ear is syringed with hot water 613
169. Diagram illustrating nystagmus when the left ear is syringed with cold water 614
170. Diagram illustrating the cause of nystagmus toward the affected side when the right labyrinth is dead and there is a cerebellar abscess upon this side 617
171. Section through the middle turn of the cochlea in a case of leucæmia, showing infiltration 678

SECTION I.

THE ANATOMY AND PHYSIOLOGY OF THE EAR.

THE ANATOMY AND PHYSIOLOGY OF THE EAR.

CHAPTER I.

THE ANATOMY OF THE EAR.

THE auditory apparatus, through the agency of which certain forms of motion are interpreted as sound, may best be considered as consisting of two parts—a conducting mechanism and a receptive mechanism. The conducting mechanism collects the vibrations of the sounding body and transmits them to the receptive mechanism, through which this motion is recognized as sound.

This division of the subject affords a much clearer view of the function of the various parts concerned in audition, in health and in disease, than that obtained by adhering strictly to the anatomical divisions of the external, middle and internal ear.

The conducting apparatus includes the external and middle ear. The middle ear is simply the more delicate and complicated portion of the transmitting mechanism, and therefore is more carefully protected from injury, both by its situation at a distance from the external surface of the body and by the presence of the membrana tympani. It is probable that the function of this structure is almost entirely protective, and that it plays but an unimportant part in the transmission of sound vibrations. That portion of the conducting tract which it separates from the outer world communicates with the surface of the body by means of the Eustachian tube; it seems wiser, therefore, to consider the external and middle ear and Eustachian tube together, rather than as individually distinct, since they perform a single function.

The second portion, the receptive mechanism, includes not only the internal ear, or labyrinth, but, in addition, the trunk of the auditory nerve, its central and cortical nuclei and fibres of association and projection. The labyrinth, then, represents but a small portion of the receptive mechanism, constituting the specialized end organ of the auditory nerve, through which vibrations in the labyrinthine fluid produce specific impressions upon the cerebrum. It can be seen at once how much more comprehensive the range of aural pathology becomes when this view is taken, than when anatomical divisions alone are followed.

I. The Conducting Apparatus.

Under this head we include the auricle and the cartilaginous meatus, the bony external auditory meatus, the membrana tympani, the tympanum, and the Eustachian tube.

The auricle and the cartilaginous meatus together form an irregularly funnel-shaped device for transmitting aërial vibrations to the deeper parts, the auricle constituting the wide portion of the funnel, the cartilaginous meatus the tubular portion.

The Auricle.—The auricle consists of a thin plate of fibrocartilage, oval in outline, attached to the side of the skull at an acute angle with the median antero-posterior vertical plane of the body. Its posterior surface is convex and smooth, while the concave anterior surface presents certain irregularities which merit special description. The unattached border of this oval cartilaginous plate is folded forward upon itself to such an extent that the free margin appears upon the anterior or external surface, forming the helix. Above, the helix does not terminate at the

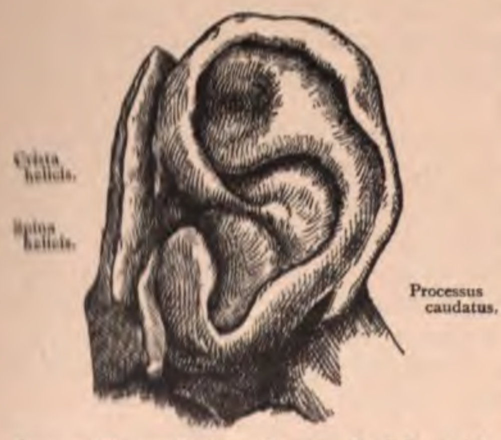


FIG. 1.—The cartilaginous framework of the auricle. (After Politzer.)

supero-anterior attachment of the auricle, but is continued backward and slightly downward from this point, as a prominent ridge, the crista helicis, which forms the superior boundary of the cartilaginous meatus.

At the base of the crest a minute spur of cartilage extends downward, constituting the spina helicis. Followed in the opposite direction, the helix is seen to terminate in an elongated cartilaginous process, the processus caudatus; the spine of the helix and the caudate process can rarely be recognized on the living subject, but are discernible upon the cadaver after carefully removing the integument covering the auricle (Fig. 1).

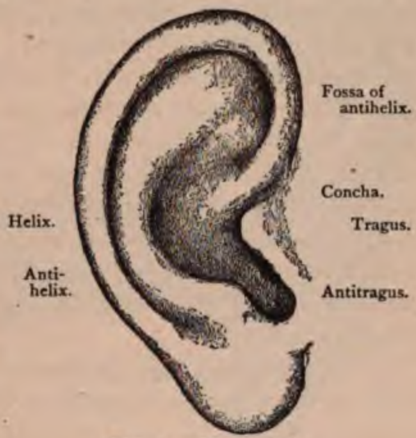


FIG. 2.—The auricle.

The groove beneath the helix is called the fossa of the helix, or scaphoid fossa. Immediately in front of this fossa is a broad convex ridge running parallel to the helix called the antihelix, dividing above into two branches—the crura helicis or the crura furcata. These crura inclose between them the fossa of the antihelix. The antihelix terminates below in a cartilaginous prominence—the antitragus. Immediately in front of the antihelix and extending downward as far as the antitragus is a deep cavity called the concha; this depression is partially divided by the spine of the helix into two unequal parts, of which the superior is the smaller and lies between the spine of the helix and the anterior crus of the antihelix, while the larger division lies in front of the antihelix and above the antitragus. As already stated, the superior margin of the cartilaginous meatus is formed by the spine of the helix; its posterior and inferior margins constitute the anterior and inferior boundaries of the concha. In front of the entrance to the meatus, slightly covering it and continuous with its anterior wall, there is a prominent cartilaginous tubercle, somewhat pyramidal in shape, called the tragus. This is separated from the antitragus by a deep broad notch, the fissura intertragica. The tragus is not completely separated from the antitragus by this fissure, the bases of the two processes becoming continuous at the junction of the anterior and inferior walls of the cartilaginous meatus. Above, the tragus is completely separated from the spine and crest of the helix, the intervening space being filled with dense connective tissue.

From the preceding description, it will be seen that while the contour of the cartilaginous margin of the auricle above, anteriorly and posteriorly, is fairly regular, its inferior margin from the processus caudatus of the helix to the fissura intertragica presents numerous irregularities of outline. These indentations are filled up by a mass of adipose connective tissue which, extending downward for a variable distance, gives a regular outline to the pinna. To this process the name of lobule is given. The walls of the irregular, funnel-shaped auricle, therefore, gradually converge to form the cartilaginous meatus.

The Cartilaginous Meatus.—The lumen of this canal is oval in shape when viewed in cross section, the long axis of the ellipse being inclined at an angle of about sixty degrees to the horizontal plane. The inner extremity of this canal is attached by means of firm bands of connective tissue to the margin of the bony meatus. The cartilaginous framework of the canal is wanting above and posteriorly, this deficiency becoming greater as the canal extends inward, until at its termination the inferior wall only is cartilaginous, being prolonged for a short distance along the floor of the bony meatus as a tongue-shaped cartilaginous process, known as the processus triangularis * (Fig. 3).

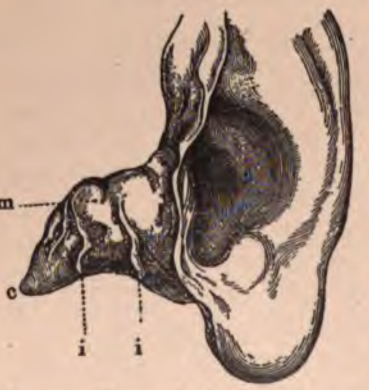


FIG. 3.—The cartilaginous meatus. (Politzer). c, Processus triangularis; i, i, Incisures of Santorini.

The wall of the canal is completed by firm connective tissue, which fills up the hiatus in its cartilaginous portion. This fibrous tissue is continuous with the periosteum of the corresponding portion of the bony canal. The anterior wall of the cartilaginous meatus presents two vertical fissures (Figs. 3 and 4) which pass completely through its substance. The spaces thus left are filled with connective tissue, with an occasional admixture of striped muscular fibres. These fissures are called the incisures of Santorini. The more extensive of the two is situated at the base of the tragus; the second is farther inward, while a third is occasionally met with beyond this. These fissures render the cartilaginous meatus more freely movable, and are important clinically, for through them deep abscesses of the parotid gland, discharging spontaneously, rupture into the canal on account of the weakness of the walls at this point. From a surgical standpoint these dehiscences are important, since they enable us to turn the auricle and fibrocartilaginous canal forward on the cheek, after separation of the posterior, inferior, and superior attachments.

---

* Politzer, Zergliederung des menschlichen Gehörorgans, 1889, p. 57.

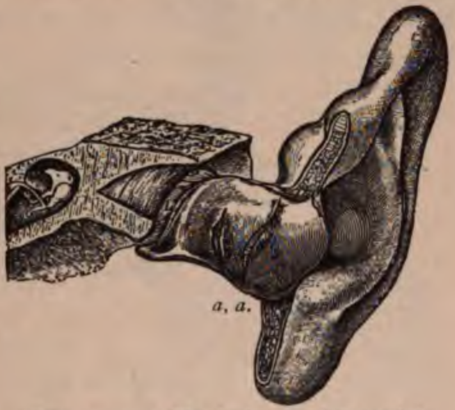


FIG. 4.—*a, a,* The incisures of Santorini. (Urbantschitsch.)

The Bony Canal.—In order properly to understand the osseous meatus, it will be necessary to consider somewhat in detail the development of the temporal bone. This portion of the skull develops from four centers: the squamous, the petro-mastoid, the auditory or tympanic, and the stylomastoid. This last center of ossification does not concern us, but the other three are of importance, as they are all integral parts of the auditory apparatus, and, with the exception of the petrous portion, all enter into the formation of the external meatus. The manner in which these various portion unite to form the temporal bone is shown in Fig. 5, which is somewhat diagrammatic.

The osseous meatus does not exist at birth, its place being supplied by a canal of fibrous tissue. Reference to Figs. 8, 9, and 10, drawn from specimens prepared by the author, renders this clear. At its inner extremity this terminates in the auditory process or the tympanic ring. The auditory process (Figs. 5 [2] and 13 [III]) consist of a thin osseous strip bent in the form of an oval, the curvilinear outline being wanting for about an eighth of its circumference at the broader pole. The concave margin of this bony ring is grooved for the insertion of the membrana tympani, and is named the sulcus tympanicus, while the ring itself is called the annulus tympanicus. The free extremity of the posterior limb of the annulus is called the spina tympanica posterior or spina tympanica minor. Just below the extremity of the anterior limb a bony spine projects backward, the spina tympanica major. The spina tympanica anterior is directed forward, and consists of a small bony tubercle lying just beneath the larger tympanic spine.

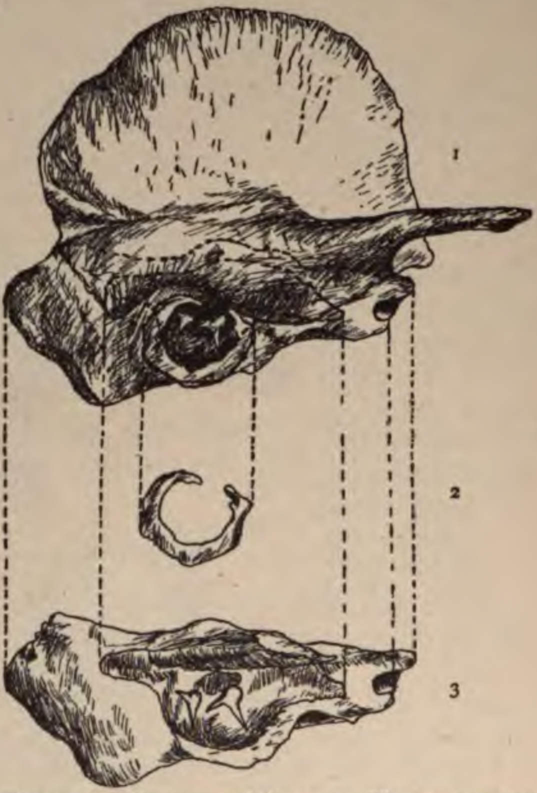


FIG. 5.—The development of the temporal bone. 1, The squamous portion; 2, The tympanic ring; 3, The petro-mastoid portion. The upper figure illustrates the union of the three portions. (Modified from Gray.)

The squamous portion of the temporal bone develops from a single center. Early in fœtal life it consists of a flat osseous scale, presenting a ridge upon its outer surface, which afterward becomes the zygomatic process. Below the root of this process is a shallow excavation, the glenoid fossa. Behind this depression the bony plate divides into two lamellæ, the inner of which is directed almost horizontally inward and forms subsequently the roof of the tympanum and of the mastoid antrum. The external lamella passes downward and somewhat inward and exhibits a deep notch upon its inferior border. The annulus tympanicus joins the external plate of the squama by the union of the free extremities of its anterior and posterior limbs to the corresponding angles of the notch above described. The curvilinear outline of the ring is completed by the notched inferior border of the external plate of the squamous portion of the temporal bone. This is shown in Fig. 6. The circlet thus completed gives attachment to the inner extremity of the fibrous canal, which occupies the position of the future bony meatus. As development progresses, the fibrous canal is replaced by osseous tissue. The annulus tympanicus is converted into a bony groove by ossification outward, and, as will be seen by consulting Figs. 8, 9, and 10, the process effects simply the separation of the superior and inferior walls, which at birth are in contact. This gutter forms the anterior, inferior, and posterior walls of the bony meatus, the superior wall being formed by that portion of the temporal bone which completes the osseous outline of the annulus tympanicus.

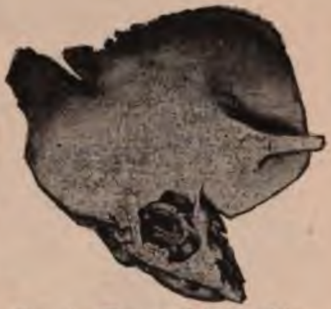


FIG. 6.—Temporal bone of infant, natural size. (Author's collection.

In the adult temporal bone (Fig. 7) the deep groove formed by the outward growth of the annulus tympanicus is called the auditory process. It is separated in front from the squamous portion of the temporal bone by a narrow fissure called the Glaserian fissure; posteriorly the auditory process enters into the formation of the mastoid squamous suture, its postero-superior termination constituting the spinum supra-meatum.

The external plate of the squama, which completes the outline of the bony meatus, during development grows almost directly outward in a horizontal direction, and nearly at right angles to that portion of the temporal bone lying above the zygomatic process. As previously stated, the fibrous tissue which occupies the place of the bony meatus at birth is gradually replaced by bone, and this part of the meatus, which at first was movable, becomes bony and rigid. As a result, the angle between the membrana tympani and the superior wall of the canal becomes apparently more acute as development advances. The actual angle of inclination of the membrane with the horizontal plane probably does not change to any degree after birth. The line of demarcation between it and the superior wall is more easily made out in older children and adults, on account of the change taking place in the meatus.

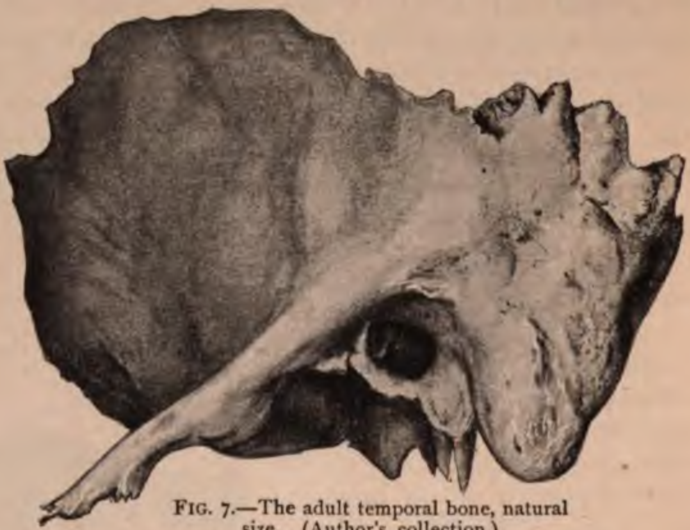


FIG. 7.—The adult temporal bone, natural size. (Author's collection.)

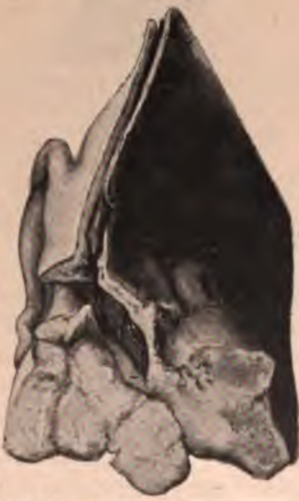


FIG. 8.—The external meatus and membrana tympani of a child at birth, natural size. The meatus has been split, and the superior and inferior walls have been held apart. (Author's specimen.)

At birth the superior and inferior walls are in contact and must be separated in order to inspect the membrana tympani, as the specimen from which Fig. 8 was drawn shows. In this specimen the anterior wall of the canal was cut through, from just in front of the tragus to the membrana tympani, and the walls separated so that the parts could be seen and drawn.

When we compare this drawing with Figs. 9 and 10, representing the same region in childhood and adult life, we see at once that the formation of the bony canal may be said to have effected this separation and made it permanent, simply by the deposit of bony tissue, rendering the fibrous tube rigid.

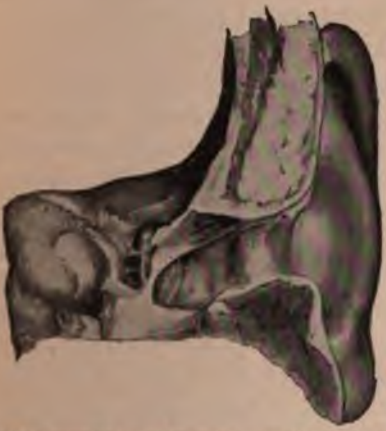


FIG. 9.—External meatus, membrana tympani, and middle ear from a child five years of age, natural size. (Author's specimen.)

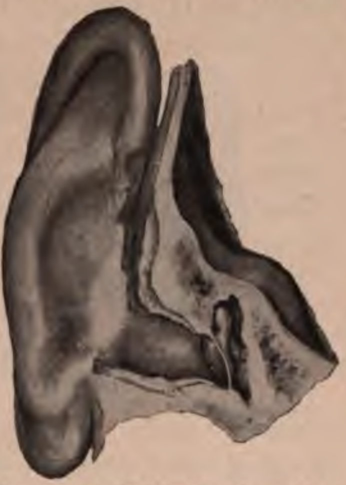


FIG. 10.—Sagittal section through external auditory meatus, membrana tympani, and middle ear of an adult, natural size. (Author's collection.)

The third portion of the temporal bone, the petro-mastoid part, consists of an oblique triangular osseous pyramid, the apex of which is directed forward and inward, while its base fills up the gap between the free margin of the squamous plate of the temporal bone and the posterior crus of the annulus tympanicus, at the same time extending forward, so that the anterior portion of this surface lies opposite the tympanic ring.

The line of union of the mastoid portion to the external squamous plate is the mastoid squamous suture. Looking at the cranial surface, we find that the petrous portion unites with the inner plate of the squama, forming the petro-squamous suture.

It is clear from the foregoing description that the base of the pyramid is made up of the outer surface of the mastoid and of that portion of the petrous bone lying below the petro-squamous suture and opposite the tympanic ring. This last region corresponds to the inner wall of the tympanic cavity, or the fundus of the external auditory meatus, the membrana tympani having been removed.

The Tympanic Cavity.—The tympanic cavity is a bony chamber the inner wall of which is formed by the external surface of the petrous portion of the temporal bone. This wall (Fig. 11) presents for inspection a rounded eminence, called the promontory, covering the first turn of the cochlea. Behind, and somewhat beneath the promontory, there is a niche called the niche of the round window, into which the fenestra rotunda opens. This niche looks almost directly backward, and even when the parts are most favorably disposed for inspection, but a very limited area of the depression is visible. Above, in the upper and posterior portion of the inner wall, is an oval fossa, the pelvis ovalis, at the bottom of which is the oval window. In Fig. 11 the stapes is in position, and fills the pelvis ovalis. The posterior wall of the pelvis ovalis is abrupt, while its anterior wall slopes gradually forward until it merges into the surface of the promontory. The inferior wall is longer and more precipitous that the superior wall. The lumen of the fenestra ovalis looks outward and downward. At birth the pelvis ovalis is separated from the niche of the round window by a deep fossa, the sinus tympanicus (seen in Fig. 6), which usually disappears completely in adult life. Above the oval window there is a distinct bony arch formed by the encroachment of the outer wall of the aqueductus Fallopii upon the tympanic cavity. The facial nerve passes through this canal. Directly above this bony ridge there is another and smaller bony crest, caused by the projection of the horizontal semicircular canal outward into the cavity of the

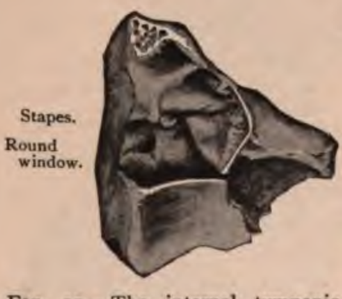


FIG. 11.—The internal tympanic wall. (Author's specimen.)

middle ear. The outer wall of the aqueductus Fallopii is occasionally incomplete, the facial nerve being then exposed in its passage through the tympanum. Behind the pelvis ovalis, at the juncture of the inner and posterior walls of the tympanum, there is a small bony pyramid, through the apex of which the tendon of the stapedius muscle passes. The plane of the inner wall of the tympanic cavity lies more nearly in the median antero-posterior vertical plane of the body than does that of the tympanic ring; hence the tympanic cavity is broader above and posteriorly, than below and anteriorly. In front of the promontory the inner wall is smooth and gradually merges into the tympanic opening of the Eustachian tube.

The anterior wall of the tympanum presents at about its centre, the tympanic orifice of the Eustachian canal. Above this, and separated from it by a thin bony plate, the processus cochleariformis, is the canal for the tendon of the tensor tympani muscle. The anterior wall is separated from the internal carotid artery as it passes through the carotid canal by a thin, bony plate. The osseous floor of the cavity lies at a considerable distance below the lower margin of the tympanic ring. It is sometimes formed of fairly compact bone, but quite frequently it is cancellous; it is in relation with the jugular fossa, which lodges the bulb of the internal jugular vein, and may present dehiscences, exposing the bulb to traumatism by instruments introduced into the meatus.

The posterior wall presents, at its junction with the internal wall, the pyramid, through the apex of which the tendon of the stapedius muscle passes. The opening into the mastoid antrum lies directly above this process. The external wall of the tympanum is formed chiefly by the membrana tympani (a structure which will be described presently), by the inner surface of the tympanic ring, and above by the inner margin of the external plate of the squama and by the angle formed by the separation of the inner and outer plates. It becomes evident, therefore, that the tympanic cavity is prolonged upward for a considerable distance above the plane of the superior wall of the meatus. This portion of the cavity is the epitympanic space or recess, or the vault of the tympanum. The portion lying below this plane is called the atrium.

The Vault of the Tympanum (Fig. 12).—The epitympanic space is somewhat pyramidal in shape, the apex lying at the angle between the two plates of the squama. These plates, with the adjoining portions of the petrous bone and the petrosquamous suture, complete two osseous faces of the pyramid; the remaining surface and the base are partly wanting, being represented by the openings leading into the mastoid antrum posteriorly, and into the tympanic cavity below. When the parts are in their normal position this lower surface is partially completed by the ossicula, their ligaments, and the reduplications of the mucous lining of the tympanum, which shut off the upper portion of the cavity more or less perfectly from the lower part.

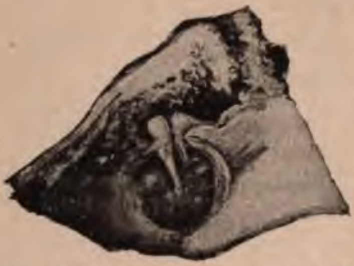


FIG 12.—The internal tympanic wall and the vault of the tympanum, with the ossicles in position. (Author's collection.)

The Ossicles (Figs. 13 and 14).—The ossicular chain is lodged within the tympanum, and serves to transmit and modify sound vibrations. It constitutes, in reality, a lever through which the impulses transmitted to the labyrinthine fluid are increased in intensity, but diminished in amplitude.

The ossicles are three in number: the malleus, incus, and stapes. According to Rathke * and Urbantschitsch,† the malleus and incus are developed from one nucleus, and subsequently become separate bones, intimately connected at their articular surfaces, while the stapes develops from a distinct centre of its own.

Gradenigo ‡ believes that the foot plate of the stapes springs from the capsule of the labyrinth, while the remainder develops from the second visceral arch, the two portions subsequently uniting.

The Malleus.—The malleus is the largest ossicle of the series, and consists of a head and shaft joined to each other at an obtuse angle by a constricted portion called the neck. The shaft or long process is prismatic on cross section, and tapers gradually from just below the neck of the ossicle to the tip, which is sometimes bent slightly forward in the form of a hook.

---

* Kiemenapp. und Zungenb., 1832, p. 122.

† Lehrb. der Ohrenheilk., Wien, 1890, p. 229.

‡ Med. Jahrbuch, Wien, 1887.

PLATE I.

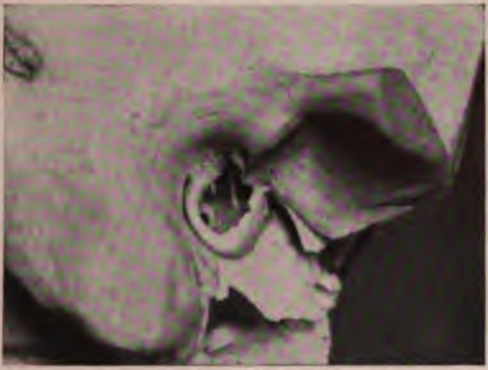


FIG. A.—ANATOMICAL PLATE.

View of tympanic ring, internal wall of middle ear, and malleus and incus as seen from without. The nitch of the round window is easily recognized below the long process of the incus. (Author's specimen.)

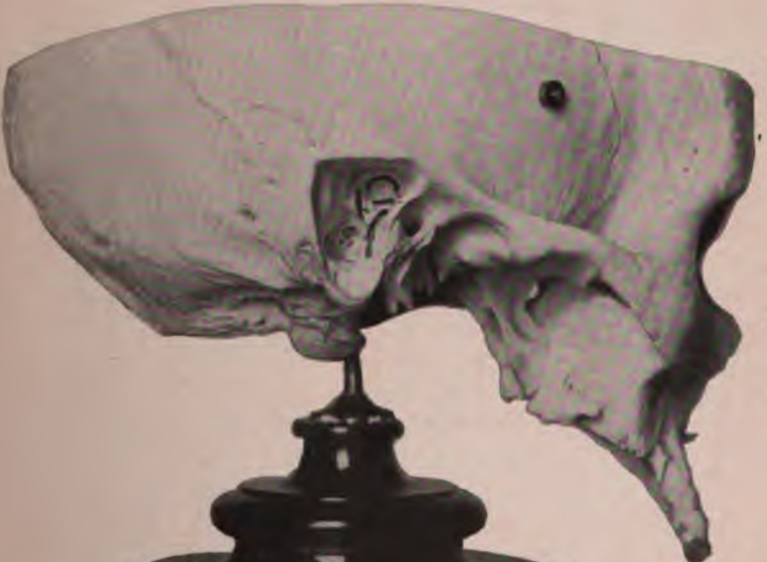


FIG. B.—ANATOMICAL PLATE.

Bony specimen showing superior horizontal and posterior semicircular canals, and the facial canal. (Author's specimen.)

PLATE II.

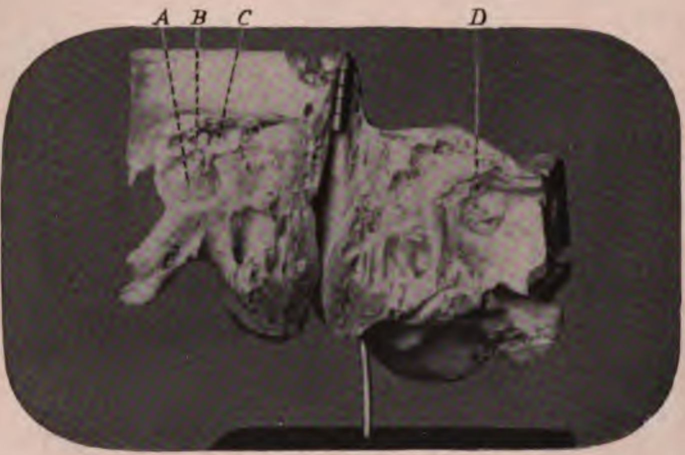


FIG. A.—ANATOMICAL PLATE.

Section through middle ear. *D*, Stapes; above the stapes is seen the canal for the facial nerve. This canal is seen to pass downward through the substance of the mastoid process. *A*, Membrana tympani. *B*, Head of malleus. *C*, Body of incus. (Author's specimens.)

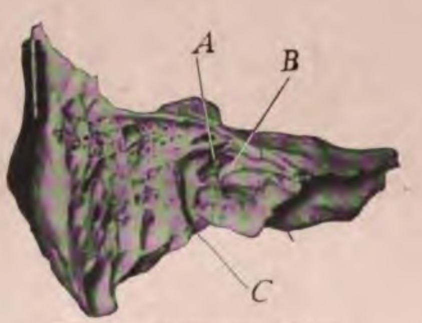


FIG. B.—ANATOMICAL PLATE.

Section through temporal bone, showing mastoid, facial canal, and internal wall of middle ear. *A*, Head of stapes. *B*, Promontory covered with branches of tympanic plexus. *C*, Facial canal. (Author's specimen.)

At the junction of the shaft with the neck there is a prominent bony tubercle called the short process of the malleus, which is directed forward and outward. The prismatic shaft presents an external border for attachment to the membrana tympani, an internal border directed toward the labyrinthine wall, and somewhat broad anterior and posterior surfaces. It is evident that any rotation of the malleus upon the long axis of the manubrium will alter the apparent breadth of the shaft as viewed through the meatus, according as the degree of rotation brings the broad anterior or posterior surface into view, or the sharp edge which marks the junction of these surfaces with the anterior border. Springing from the an-

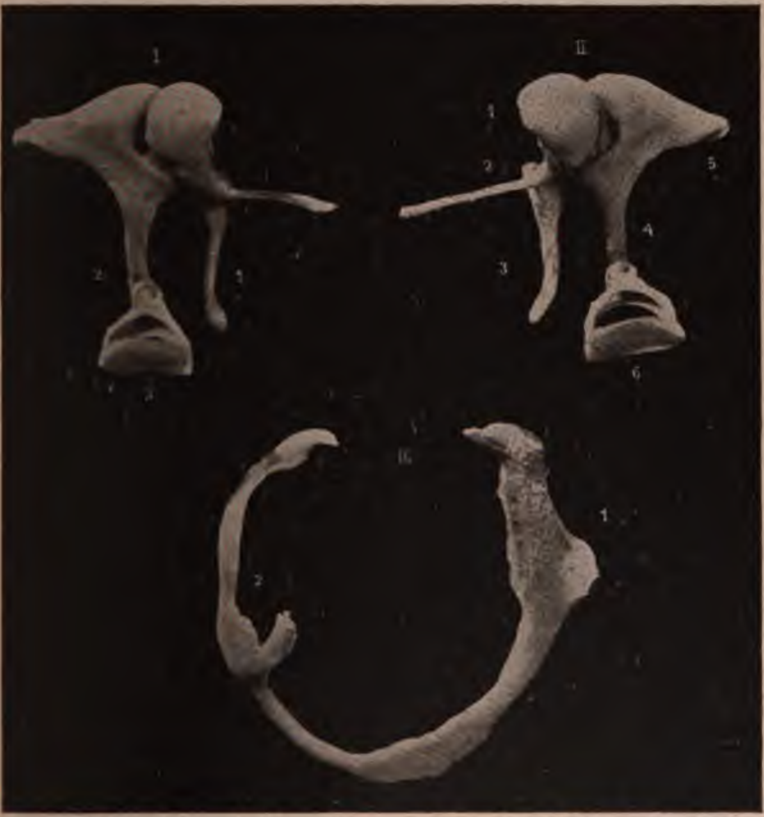


FIG. 13.—The ossicles and the annulus tympanicus. I, Ossicular chain of left ear. 1, Malleus; 2, Incus; 3, Stapes. II, Ossiculus chain of right ear. 1, Malleus; 2, Processus folianus; 3, Manubrium; 4, Long process of incus; 5, Short process of incus; 6, Stapes. III, Annulus tympanicus. 1, Anterior tubercle; 2, Posterior tubercle. (Rüdinger: Blake's translation.)

terior surface just below the short process is a long, delicate, bony spicule, the processus folianus or gracilis, which lies in the Glaserian fissure, and in adult life is frequently imbedded in the fibres of the anterior ligament. The external surface of the neck of the malleus is roughened for the attachment of the external ligament. The anterior surface of the neck and

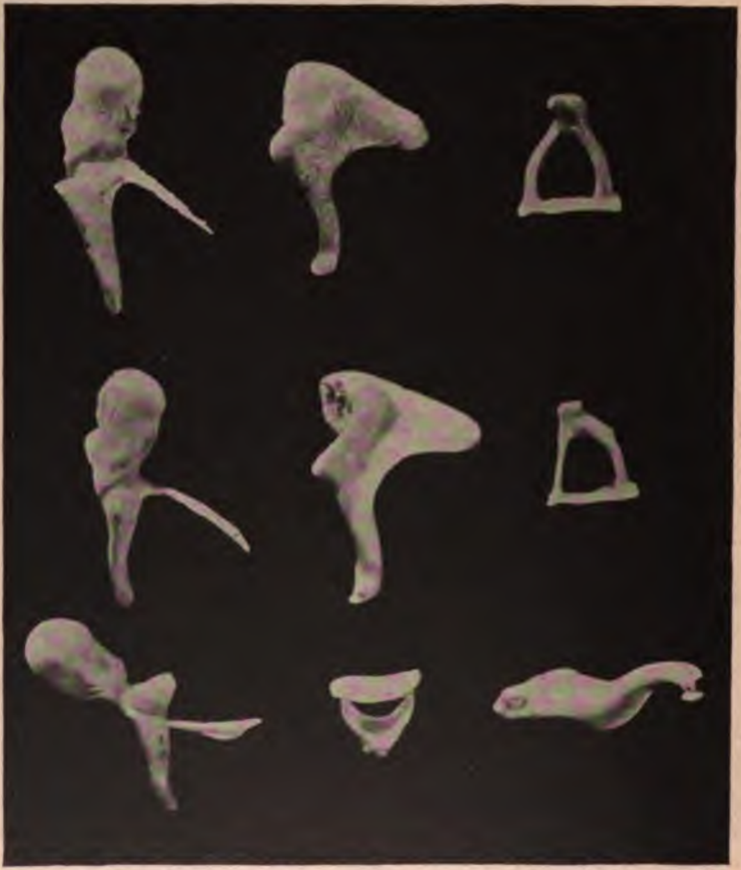


FIG. 14.—The malleus, incus, and stapes in various positions. (Rüdinger: Blake's translation.)

the adjoining portion of the head are deeply grooved for the insertion of the anterior ligament. The head is irregularly spherical in shape, the spherical contour being encroached upon posteriorly by the saddle-shaped surface for articulation with the incus, while anteriorly there is a groove for the attachment of the anterior ligament.

The Incus.—The central ossicle of the chain consists of a body and two processes. The short or horizontal process—a continuation of the body—is conical in shape and extends backward, its tip resting in a little pit or fossa in the posterior tympanic wall, just below the entrance to the mastoid antrum. This depression is called the sella incudis. The body of the bone is flattened from before backward, the vertical diameter being about double the transverse. The anterior surface, forming the base of the cone, is saddle-shaped for articulation with the malleus. The long or descending ramus of the incus is a long, tapering bony shaft, extending downward from the antero-inferior angle of the body ; its lower extremity is bent inward so that the tip of the process is directed toward the internal tympanic wall. This free extremity is called the lenticular process, and articulates with the head of the stapes. The lenticular process in fœtal life is represented by a separate bone, the os orbiculare.

The Stapes.—The innermost ossicle of the series brings the conducting mechanism into immediate relation with the receptive apparatus. As the name implies, it is stirrup-shaped, and consists of a small rounded head the external face of which is hollowed out for articulation with the lenticular process of the incus; below the head is a constricted portion called the neck, from which the crura diverge. The posterior crus is the longer and more curved. The crura terminate in an oval or kidney-shaped plate of bone, the foot-plate of the stapes, which closes the oval window. The entire stapes lies almost wholly within the pelvis ovalis, hence when the membrana tympani is wanting it is well protected from traumatism from instruments introduced through the canal. The stapes lies obliquely in the oval niche, being nearer to the inferior and posterior walls of the fossa than to the anterior and superior. Since the posterior wall of the niche is almost vertical, the corresponding stapedial crus lies close to it, and adhesions between this wall and the posterior limb of the ossicle are of frequent occurrence.

The ossicular chain is suspended in the tympanic cavity by a series of ligaments which bind the individual members of the chain to each other and to the walls of the tympanum.

Ligaments of the Malleus (Fig. 15).—These are four in number : the anterior, external, posterior, and superior or suspensory ligament.

The anterior ligament is the strongest of these. It arises from the spina tympanica major and from the walls of the Glaserian fissure, some of the fibers traversing the length of the fissure and taking their origin from the spine of the sphenoid. From this extensive origin they pass outward, upward, and backward, and are inserted into the anterior surface of the neck of the malleus and into the depression found on the anterior surface of the head. They inclose the processus folianus of the malleus.

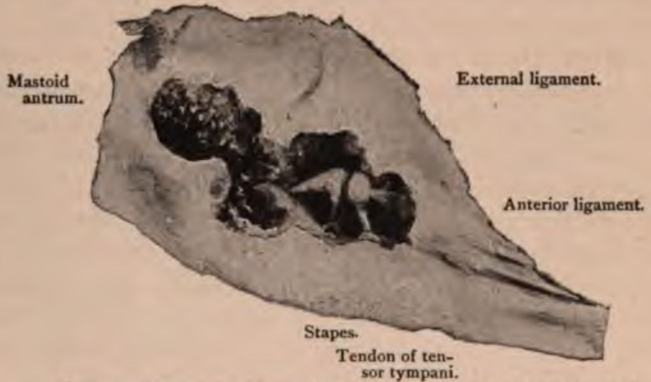


FIG. 15.—The tympanum from above. (Author's specimen.)

The external ligament is somewhat fan-shaped. It springs from the external roughened surface of the neck of the ossicle, from which point the fibers diverge to be inserted into the free margin of the inner extremity of the superior wall of that portion of the bony meatus formed by the external plate of the squama. The posterior fibres, according to Helmholtz, form a distinct band called the posterior ligament of the malleus.*

This portion of the external ligament, together with the anterior ligament, forms the axis band of the hammer, since the axis of rotation of the ossicle is approximately a line drawn through the attachment of these two ligamentous structures.

The superior ligament is a delicately rounded band of fibrous tissue running from the tegmen tympani downward to the head of the malleus.

The Ligaments of the Incus.—The incus is bound to the tympanic wall by a single fibrous band, the posterior ligament, which extends from the lateral aspects of the short process near its extremity to the posterior wall of the tympanum. At its origin it is dense in structure, owing to the somewhat limited area from which it arises. From this point the fibres diverge rapidly and divide into two bundles to be inserted into a broad area on the posterior wall of the tympanum. On account of this broad insertion it is sometimes called the fan-shaped ligament of the incus. The inferior surface of the short process lies in a shallow depression in the tympanic wall called the sella incudis, the opposing surfaces being covered with cartilage.

---

* The Mechanism of the Ossicles. Translated by Buck and Smith, New York, 1873.

The Ligaments of the Stapes.—The foot plate of the stapes is confined in the oval window by the stapedio-vestibular or annular ligament. The margins and vestibular surface of the foot plate and the periphery of the oval window are covered with hyaline cartilage, the annular ligament developing from the perichondrium.

Interossicular Ligaments.—The malleus and incus are bound together by a loose capsular ligament, the articular surfaces of the ossicles being covered with cartilage. The incudo-stapedial articulation is similar in character.

The Eustachian Tube.—Having traced the bony and cartilaginous framework of the conducting mechanism inward to the point where it joins the receptive portion of the auditory apparatus at the oval window, we have next to consider the characteristics of that passage by means of which certain delicate parts of this system can be protected by a fibrous

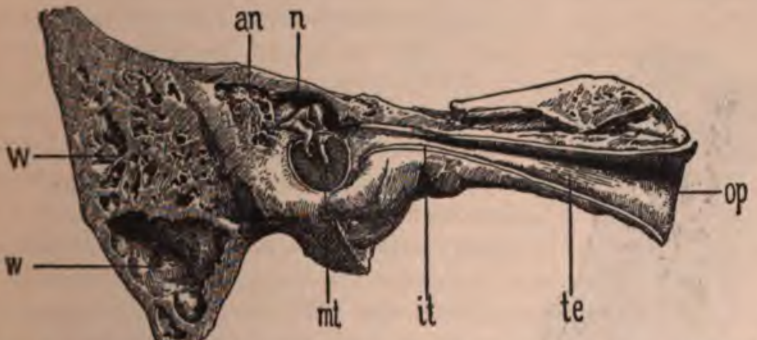


FIG. 16.—Section through mastoid, tympanum, and Eustachian tube. (Politzer.) W, W, Mastoid cells; mt, Membrana tympani; an, Antrum; n, Vault of tympanum; it, Isthmus of tube; te, Eustachian tube; op, Pharyngeal orifice of tube.

covering without interfering with the transmission of sound waves. By means of the canal now to be described an equal atmospheric pressure is maintained upon either side of this protecting septum. This passage is the Eustachian tube. It is made up of two portions—the tympanic or bony, and the pharyngeal or cartilaginous portion—their point of junction being called the isthmus of the tube. The osseous segment is about half an inch in length, and, extending from a somewhat wide orifice just above the middle of the internal wall of the tympanum, narrows quickly as it passes downward, forward, and inward through the substance of the petrous portion of the temporal bone, until at the isthmus its diameter varies from one twenty-fifth to one twelfth of an inch. The canal is irregularly triangular in shape, the vertical diameter being double the transverse. This osseous tube is joined at the isthmus to the cartilaginous portion by fibrous tissue, the parts uniting at an obtuse angle, the opening of which is directed downward and forward. The pharyngeal portion measures about an inch in length, and at the isthmus its lumen corresponds to that of the osseous channel. As it extends downward into the pharynx, however, it grows wider, and at the pharyngeal orifice measures from one eighth to one fifth of an inch in diameter, the vertical diameter being greater than the transverse. This portion of the canal is fibrocartilaginous. The posterior wall is formed by a plate of cartilage, the upper border of which is bent first forward and then downward, so that a transverse section would be hook-shaped (see Fig. 17). The space inclosed by the bending forward of the cartilage forms the superior portion of the lumen of the tube, the interval between the free margin of the angular portion and the lower border of the cartilaginous plate being filled with fibrous and muscular tissue, thus completing the canal. We see, therefore, that the posterior, superior, and a small portion of the anterior wall of the tube is cartilaginous, while the remainder of the anterior and entire inferior wall is fibrous, the passage being slitlike rather than circular on cross

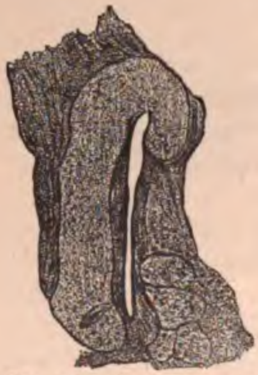


FIG. 17.—Transverse section of Eustachian tube. (After Zuckerkandl.)

section, with the anterior and posterior walls in contact except at the upper part. The membranous tube is attached to the inner extremity of the bony canal, the posterior cartilaginous plate uniting with a prolongation of the corresponding bony wall. Beyond the isthmus the tube is suspended from the base of the cranium by fibrous bands passing to its superior wall, until it terminates in the lateral aspect of the pharyngeal vault.

As described in the foregoing pages, the conducting mechanism consists of a canal, the walls of the central portions being osseous, while at either extremity they are fibrocartilaginous, communicating upon one side with the outer surface of the body directly, while upon the other this communication is effected indirectly through the oral and nasal passages. This tube is brought into intimate relation with the receptive mechanism through the agency of the ossicular chain, and at this point the osseous conduit is dilated, forming the tympanum. This chamber, situated midway in the passage, is occupied by a special device for bringing the two portions of the auditory apparatus into relation with each other. For the protection of the intratympanic parts chiefly, and, to a certain extent, to aid in the transmission of sonorous impulses, a fibrous partition divides the external auditory meatus from the tympanum and Eustachian tube. This partition constitutes the membrana tympani.

The Membrana Tympani.—The membrana tympani consists of a transverse fibrous septum, lying in the middle of the conducting tube, and bounded by the tympanic ring, which, it will be remembered, is incomplete at its upper part. This connective-tissue lamella, called the substantia propria of the drum membrane, is inserted into the sulcus tympanicus. At the point of insertion the fibrous tissue is somewhat thickened, forming the annulus tendinosus, sometimes called the cartilaginous ring. From the cartilaginous ring certain connective-tissue fibres extend outward to the periosteum of the meatus, while others, passing in the opposite direction, merge into the periosteal lining of the tympanum. The substantia propria is made up of two layers. In the outer layer the fibres radiate from the tip of the malleus toward the peripheral wall, while in the internal layer they are disposed in concentric circles about this point as a centre. The manubrium of the malleus joins the substantia propria through the interposition of a thin cartilaginous lamella which extends along its outer border from the processus brevis to the umbo, the fibres of the membrane being continuous with the perichondrium of this cartilaginous plate. At the tip of the manubrium both the circular and radiating fibres are attached directly to the ossicle, while above this point, along the external border, the attachment is effected through the interposition of the cartilaginous plate above described. This cartilage is firmly fixed at the tip of the manubrium, while the attachment at the short process is less firm and permits of a certain amount of separation from the short process. The superior border of the lamina propria joins the anterior and posterior extremities of the annulus tympanicus, constituting a tense, fibrous band, divided by the short process of the malleus into two parts. The sharply defined superior margin of the membrana propria extending from the processus brevis to the posterior extremity of the annulus is called the posterior fold The corresponding anterior fold is less prominent and shorter than the posterior. From the description it will be observed that the fibrous septum stretched across the canal is wanting where the curved outline of the annulus is completed by the auditory plate of the temporal bone. This space is the Rivinian segment or notch, and its closure will be explained later, since it is effected by the cutaneous lining of the external auditory meatus.

The Epithelial Investment of the Conducting Apparatus.—The auricle is covered with integument which is continuous with that of the face. It is somewhat loosely attached upon the posterior surface, but upon the anterior aspect is applied closely to the cartilage, the deep layer being intimately associated with the perichondrium. The tegumentary covering of the auricle is continued into the external auditory meatus, its thickness decreasing as we pass inward, until in the bony canal its deep layer forms the periosteum. The cutaneous lining of the meatus along the supero-posterior wall is thicker and more loosely attached than elsewhere, and is richly supplied with blood vessels. The covering of the superior wall of the canal passes from the internal margin of the auditory plate to the neck of the malleus, just above the short process, filling up the Rivinian notch and completely separating the external meatus from the tympanum. In comparison with the remaining portion of the membrana tym pani, it hangs somewhat loosely from the canal wall, and is called the membrana flaccida, or Shrapnell's membrane. Its fibrous layer is particularly well developed along the anterior and posterior borders, causing it to assume a somewhat triangular shape. These distinct fibrous bands constitute the fibres of Prussak. They extend from the anterior and posterior extremities of the Rivinian segment to the base of the processus brevis, and, passing along the manubrium, are lost in the external layer of the membrana propria. The space between the anterior ligament and the membrana flaccida is called Prussak's space. The epithelial covering of the meatus continues over Shrapnell's membrane, and covers completely the external surface of the drum membrane, forming its external or epithelial layer. The auricle, the meatus, and the superficial layer of the membrana thus constitute an elongated blind pouch, not unlike the finger of a glove, the drum membrane answering to the closed tip of the glove finger.

The integument of the auricle is supplied with sweat glands and sebaceous follicles. In the region of the tragus and antitragus, and for some distance within the cartilaginous canal, hair follicles are frequently found. The sebaceous glands in the meatus are somewhat altered in structure, constituting the ceruminous glands. These are not distributed beyond the junction of the cartilaginous meatus with the osseous portion, except for a small area along the upper and posterior wall, where they encroach slightly upon the bony canal. The glands are larger upon the upper wall of the canal, and are most numerous at the junction of the bony with the fibro-cartilaginous portion.

The tympanum and Eustachian tube are lined with mucous membrane continuous with that of the naso-pharynx. This membrane extends outward through the tube, covering its walls and forming the lining of the tympanum. It passes over the internal surface of the membrana tympani, constituting its internal layer; in various localities it is folded upon itself as it passes over the various intratympanic structures, giving rise to the so-called reduplications of mucous membrane within the tympanum. The most constant of these reduplications constitute the anterior and posterior pockets of the membrana (Fig. 18), while other folds whose location and disposition are not as constant are also met with. The lining in the cartilaginous portion of the Eustachian tube is thick and loosely attached, being thrown into longitudinal folds in the lower part. In the osseous tube and tympanum it is closely applied to the underlying structures constituting the periosteum. The epithelium is of the cylindrical ciliated variety in the tube and in the lower portion of the tympanic cavity, according to Politzer,* it changes to flat, ciliated epithelium above.

The mucous membrane is supplied with mucous glands, which are extensively developed in the cartilaginous tube near the pharyngeal orifice, and diminish in number in the bony tube and tympanic cavity. In the middle ear they are mostly confined to the tubal orifice, although they are occasionally found over the promontory. The membranous portion of the Eustachian tube is quite richly supplied with lymphatic tissue, which occurs both in the diffuse form and, aggregated into masses, in the form of true lymphatic nodules. To these Gerlach † gives the name of tubal tonsil. The presence of this lymphatic tissue has also been demonstrated by Sappey,‡ Ostmann,# and Teutleuben.‖

The Pockets of the Membrana Tympani and other Reduplications of the Mucous Membrane (Figs. 18 and 19).—The pockets of the membrana tympani are the most constant of the reduplications which the lining of the cavity forms. The mucous membrane lining the tympanum is attached firmly to the drum membrane, to the bony internal wall, and to the walls of the irregular spaces which lie between the membrana tympani and the structures contained within the middle ear and in immediate relation with the membrane. After being reflected over the contiguous bony and ligamentous parts it

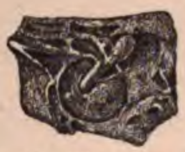


FIG. 18.—The pockets of the membrana tympani. (After Zuckerkandl.)

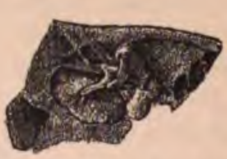


FIG. 19.—The malleo-incudal articulation covered by the superior malleo-incudal fold. (After Zuckerkandl.)

---

* Lehrb. der Ohrenheilk., Wien, 1893, p. 28.

† Arch. für Ohren., vol. x, p. 53.

‡ Traité d'anatomie déscriptive, Paris, 1877, p. 865.

Virchow, Archiv, vol. xxxiv.

‖ Zeit. für Anat. und Entwicklungsgeschichte, 1876, vols. iii and iv, p. 298.

hangs downward into the tympanic cavity in folds somewhat like a curtain. The free borders of these folds are sharply marked and constitute the folds of the pockets. The anterior fold lies in front of the malleus, and the posterior behind it. The anterior pocket is the space included between the neck of the malleus behind, the annulus tympanicus in front, the membrana tympani on the outer side, and the spina tympanica major and the anterior ligament on the inner side. At its apex it sometimes communicates with the chamber of Prussak. The posterior pocket is larger, and is traversed by the chorda tympani nerve and the posterior ligament of the malleus. Its free border—the posterior fold—may extend downward as far as the middle of the manubrium. This is a point of practical importance in middle-ear operations, since after the division of the membrana tympani, this fold, if extensive, may completely hide the incus, to the long process of which it is frequently firmly attached. I have met with this condition several times, and unless one remembers the possibility of such an anomaly, its presence may prove a source of annoyance. In one case of exploratory tympanotomy performed under local anæsthesia, the posterior fold was long, thick, and adherent to the descending arm of the incus and to the membrana tympani. An incision through the membrana, instead of exposing the incudo-stapedial articulation, brought into view a thick vascular lamella of mucous membrane which demanded repeated incision before the long arm of the incus could be recognized or the inner wall of the tympanum seen. In another instance the fold was thin, but invested the incudo-stapedial articulation and long arm of the incus so completely that exploratory tympanotomy revealed, immediately after displacement of the flap, nothing but a smooth, glistening surface, which appeared to be the inner wall of the middle ear. No landmarks could be made out; a fact which showed that the inner tympanic wall had not been exposed, and it was not until the mucosa was divided by a vertical incision that the promontory and the niche of the round window could be seen. In acute inflammatory conditions I have seen exudation encapsulated in the tympanum on account of an anomaly in the posterior pocket. The boundaries of the posterior pocket will be made clear by bearing in mind those of the anterior space, its exact analogue.

The other mucous folds within the tympanum will not be described in detail on account of their endless variety, but a general account of their usual position and direction is necessary, since their presence is often of great importance both as affecting the outcome of inflammatory processes within the tympanum, and increasing the difficulty of certain operative procedures. These folds differ from the true ligaments only in their density. They have been extensively studied by Blake,* Bryant,† Zuckerkandl,‡ and others.

In general they may be classified, according to their direction, as vertical or horizontal, and according to their situation, as those radiating from the axes of the long bones, those disposed about the stapes and the adjoining tympanic walls, and those stretching from the ossicular ligaments and the tendons of the intratympanic muscles to the ossicles and to the tympanic walls. The horizontal folds may completely shut off the vault of the tympanum from the atrium, and the vertical folds may be so extensive as to inclose the entire ossicular chain except the manubrium of the malleus.

The horizontal folds exert an important influence on acute and chronic inflammatory processes within the middle ear, their presence favoring the invasion of the mastoid process and cranial contents. The vertical folds not only act as obstructors to the conduction of sound by their weight and by the increased tension which they cause, but are of great annoyance to the surgeon in the performance of delicate operations upon the tympanum, as they may completely hide important structures. Their presence, therefore, should be borne in mind in the consideration of all pathological processes within the middle ear, as in this way many appearances which are otherwise inexplicable may be correctly interpreted, or an operator may be able to accomplish an end which a hasty view of the cavity had led him to believe would be impossible. It need only be remembered that no hard-and-fast rule can be given for their location, and that almost any of the folds may occur together.

The Muscles.—The muscles of the conducting mechanism include those passing from the auricle to the skull, the intrinsic muscles of the auricle and canal, the intratympanic muscles, and those in the walls of the Eustachian tube.

---

* Arch. of Otol., vol. xix, p. 209.

† *Ibid.*, p. 217. Burnett's System of Diseases of the Ear, Nose, and Throat, Philadelphia, 1893, vol. i, p. 55.

‡ Schwartze's Handbuch der Ohrenheilk., Halle, 1893, vol. i, p. 21.

The auricle is bound to the skull posteriorly by the mastoid fascia, the fibres of which interlace with the perichondrium and fibrous tissue of the canal, and anteriorly by the temporal fascia, which is firmly attached to the helix.

The extrinsic muscles are three in number, and are unimportant in man, though in some of the lower animals they reach a high degree of development. They are the retrahens aurem, attollens aurem, and attrahens aurem.

The retrahens arises from the mastoid region by short aponeurotic fibres, and is inserted into the cartilage of the auricle upon its posterior and inferior aspect. Its point of origin is fixed only when the occipital portion of the occipito-frontalis is rigid.

The attrahens arises from the epicranial aponeurosis at its lower border, and is inserted into the spine of the helix upon its cranial surface.

The attollens arises from the occipito-frontalis aponeurosis. The fibres converge to the point of insertion upon the upper part of the cranial surface of the auricle.

The intrinsic muscles consist of poorly developed bundles of muscular fibres distributed between the various cartilaginous processes of the auricle. Theoretically, their action would serve to alter the shape of the pinna, but from their imperfect development they are unimportant. They are situated chiefly upon the external surface of the organ. In the external meatus a few fibres of muscular tissue are found mixed with the fibrous bands which fill the incisures of Santorini.

A muscular slip is occasionally found extending from the styloid process upward to the cartilaginous meatus.

The intratympanic muscles are the tensor tympani and the stapedius.

The tensor arises from the upper wall of the cartilaginous Eustachian tube and from the walls of the bony canal which inclose it. It enters the middle ear through an osseous conduit at a point just above the tympanic orifice of the Eustachian tube, from which it is separated by a thin plate of bone—the processus cochleariformis. The tympanic extremity of this process is pyramidal in shape, and is often called the anterior pyramid. The tendon winds about this projection almost at a right angle, crosses the cavity of the middle ear, and is inserted along the inner border of the shaft of the malleus just below the neck, some of the fibres passing for a considerable distance down the manubrium, and spreading somewhat upon its anterior surface.

The stapedius arises from the interior of the pyramid found upon the postero-internal tympanic wall in front of and below the aqueductus Fallopii. The fibres converge into a tendon which pierces the apex of the pyramid and is inserted into the neck of the stapes at the point of union with the posterior crus.

The muscles of the Eustachian tube are the tensor palati, or spheno-salpingo-staphylinus, and the levator palati, or petro-salpingo-staphylinus.

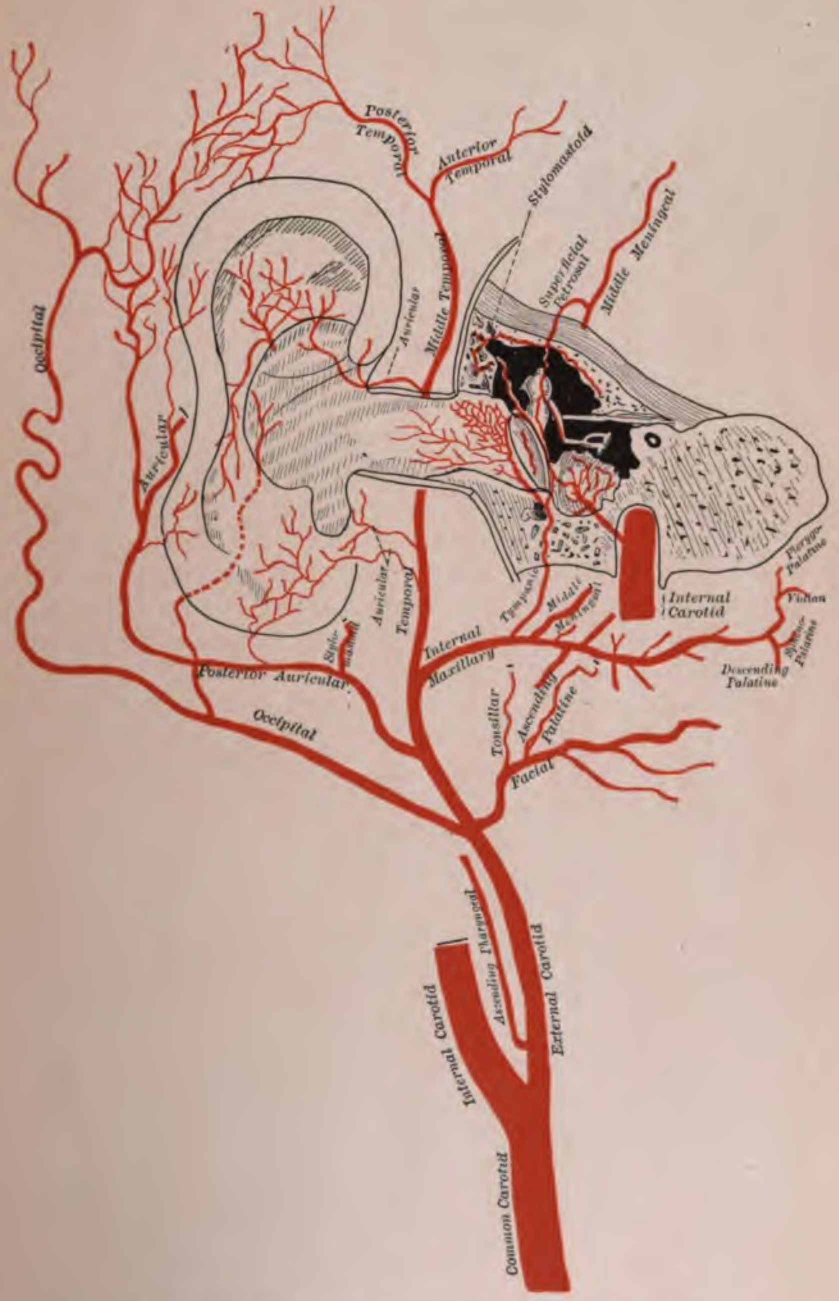
The tensor palati exerts the most influence upon the lumen of the Eustachian canal. It arises from the scaphoid fossa and spine of the sphenoid bone in front of the membranous portion of the tube, some of its fibres springing from the inferior border of the cartilaginous hook. The muscle then passes downward in front of the membranous portion of the canal, converging into a tendon which winds around the hamular process of the sphenoid and expands into a broad aponeurosis which is inserted into the anterior surface of the soft palate and into the posterior bony margin of the hard palate, the fibres uniting with those of the opposite side in the median raphé.

The levator palati springs from the quadrilateral surface on the inferior aspect of the petrous bone, near its apex, and passes downward, forward, and inward to its insertion on the posterior and superior surface of the soft palate. The body of the muscle lies along the inferior margin of the cartilaginous plate which forms the posterior wall of the tube, to which it is loosely attached. It is also in contact with the fibrous inferior wall.

A third muscle, sometimes included in this group, is the salpingo-pharyngeus, a muscular slip, which runs from the body of the palato-pharyngeus upward and forward to be inserted into the inferior wall of the tube.

The Arteries (Plate III) of the conducting apparatus are derived chiefly from the external carotid artery, although a few branches spring from the internal carotid. The branches of the external carotid supplying the auricle, canal, and middle

PLATE III.



THE ARTERIAL SUPPLY OF THE CONDUCTING APPARATUS.

ear are the posterior auricular, the superficial temporal, the occipital, the internal maxillary, and the ascending pharyngeal.

The posterior auricular is distributed to the posterior portion of the auricle and the corresponding part of the meatus. Through the stylomastoid branch which enters the stylomastoid foramen it supplies the mastoid cells, and sends a special branch to the stapedius muscle and to the stapes. It anastomoses with the superficial petrosal of the middle meningeal artery within the tympanic cavity, and with the tympanic branch of the internal maxillary, forming with this latter a complete vascular circle about the inner extremity of the meatus.

The superficial temporal, through the superior and inferior anterior auricular arteries, supplies the anterior portion of the pinna and canal, the vessels anastomosing with the branches of the posterior auricular artery; it also sends a small branch to the tympanum through the Glaserian fissure.

The occipital artery sends branches to the concha, the vessels entering upon its cranial surface.

The internal maxillary, through the middle meningeal and tympanic branches, is the most important source of blood supply, especially in early life. Before entering the cranium it sends a few twigs to the Eustachian tube. Within the skull it gives off the superficial petrosal, which enters the tympanum through the petro-squamous suture, and is distributed to the roof of the middle ear, to the malleus and incus, and to a portion of the internal tympanic wall, where it anastomoses with the labyrinthine vessels, according to Politzer.* Within the Fallopian canal it communicates with the stylomastoid branch of the posterior auricular.

The tympanic branch of the internal maxillary enters the middle ear through the Glaserian fissure, supplying the anterior portion of the cavity, and anastomoses with the stylomastoid branch of the posterior auricular upon the periphery of the tympanic membrane. In early life this artery is much larger than the stylomastoid, and the vascular circle about the margin of the membrane from which the numerous vessels pass outward to the posterior wall of the meatus seems to spring from the tympanic branch of the internal maxillary; hence this artery is sometimes called the auricularis profunda.

---

* Archiv für Ohrenheilk., vol. xI, p. 237.

On the internal wall of the middle ear the tympanic artery anastomoses with the tympanic branches of the internal carotid and with the Vidian branch of the internal maxillary. In addition to the two branches of the internal maxillary named above, the Vidian, the descending palatine, and the pterygopalatine arteries, all springing from this trunk, send small vessels to the Eustachian tube and to the tubal muscles; the descending palatine anastomoses freely with the ascending palatine branch of the facial and with the ascending pharyngeal branch of the external carotid artery.

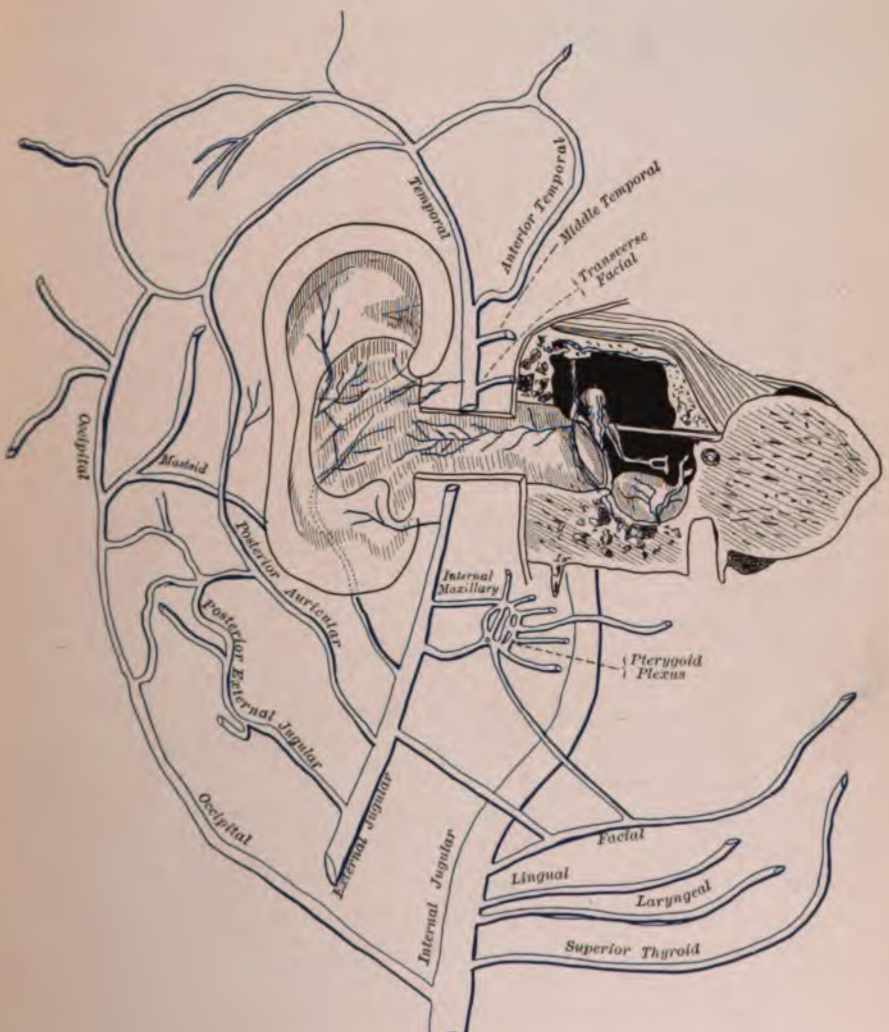
In its passage through the carotid canal the internal carotid sends branches to the tympanum, which anastomose with the tympanic and Vidian branches of the internal maxillary.

The Veins (Plate IV).—The veins are rather irregular in their distribution, but in general follow the course of the arteries. Most of the vessels from the deeper regions form a plexus upon the superior and supero-posterior walls of the external auditory meatus; as they approach the orifice of the meatus the various venous channels anastomose freely with one another. Those on the posterior aspect of the canal and auricle pass into the external jugular and mastoid veins, while the anterior branches go to join the temporal and facial veins. Some of the deeper vessels pass into the pterygoid plexus. The veins of the Eustachian tube follow the course of the arteries distributed to this region, and empty into the internal jugular directly, or occasionally communicate with the facial, the lingual, or the superior thyroid veins. Between the internal pterygoid muscle and the adjacent wall of the tube a trunk of considerable size establishes communication with the cavernous sinus; near the pharyngeal orifice of the Eustachian canal there is, according to Zuckerkandl,* a venous plexus communicating with the turbinated bodies in the nasal cavities. The free anastomosis of the veins which return the blood from the deeper portions of the conducting mechanism is of particular importance from a therapeutic point of view, since this intercommunication between the various channels is comparatively superficial, and enables us to relieve deep-seated congestion by phlebotomy. The combined area of

---

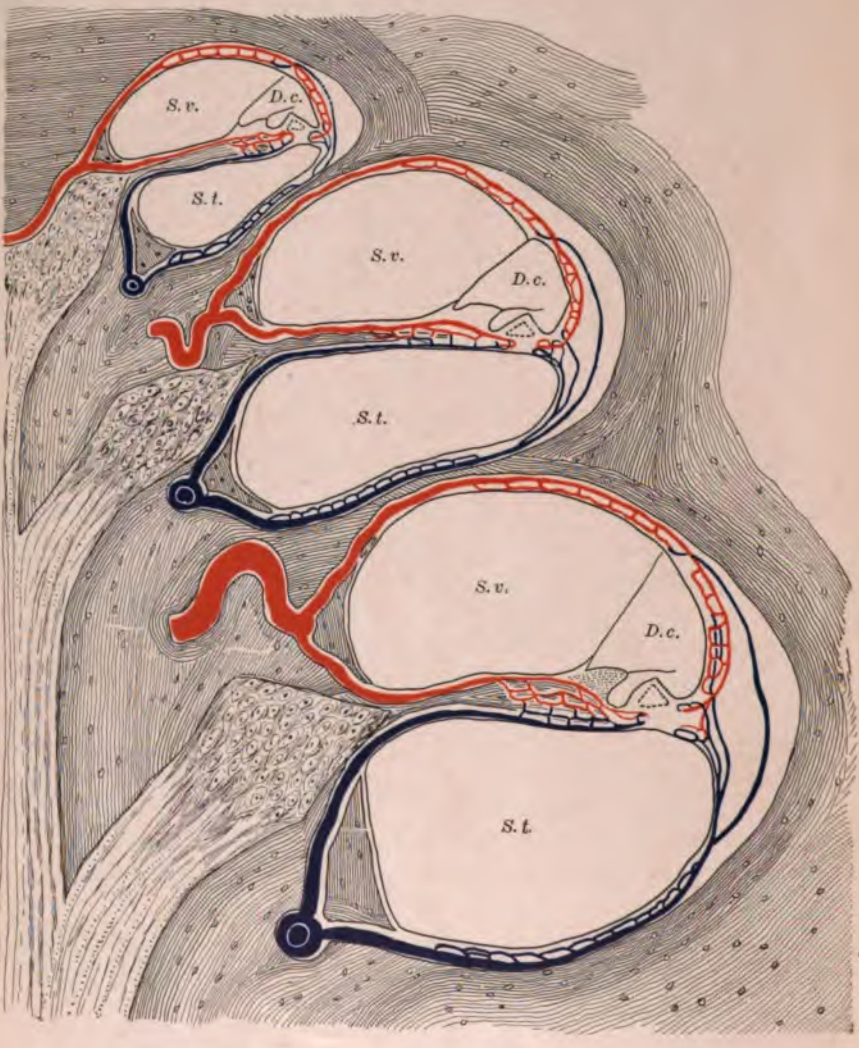
* *Op. cit.*, p. 38.

PLATE IV.



THE VENOUS SUPPLY OF THE CONDUCTING APPARATUS.

PLATE V.



THE VASCULAR SUPPLY OF THE COCHLEA. (Modified from Hyrtl.)

the veins is much greater than that of the arteries—a fact which in itself tends to cause the spontaneous resolution of any inflammatory process which may arise. Within the tympanum the circulatory arrangement is somewhat unique, the capillaries being very short, or entirely wanting, and the arterial blood passes directly into the veins without the interposition of the capillary system, as demonstrated by Prussak.*

The Lymphatics.—The lymphatic channels are freely distributed and anastomose both with the superficial lymph glands and with those forming the submucous lymphatic system of the pharynx. The superficial lymphatics over the mastoid, the lymph nodules in front of the auricle, and those situated in the cervical region between the platysma and the sternomastoid muscles are all intimately associated with the lymphatic channels of the meatus and tympanum, while free lymphatic anastomosis exists in the opposite direction through the medium of the glands situated in the lateral pharyngeal walls. The lymph channels of the membrana tympani itself are arranged in three systems, one for each layer. These communicate freely with each other and with the lymphatic network of the external meatus.

The Nerves (Figs. 20 and 21).—The muscles of the conducting apparatus derive their innervation from the trigeminus, the facial, and the cervical plexus. The *cervical plexus*, through the occipitalis minor, supplies the attollens aurem; the *trigeminus*, through the otic ganglion, supplies the tensor tympani and the tensor palati muscles; the *facial* supplies the other muscles, either directly or through its ganglionic communications.

The sensory nerves are derived from the cervical plexus, trigeminus, pneumogastric, and the glosso-pharyngeal trunks. The *auriculo-temporal*, a branch of the trigeminus, supplies the auricle, the upper part of the meatus, and the membrana tympani. The *auricularis magnus*, from the cervical plexus, is distributed principally to the posterior part of the auricle and meatus, anastomosing with the auricular branch of the pneumogastric upon the posterior wall of the canal.

The auricular branch of the vagus supplies the cartilaginous canal and a portion of the posterior surface of the auricle. *The tympanic branch of the glosso-pharyngeal* enters the middle ear through a foramen in the floor of the cavity, and is distributed to its lining membrane and to the Eustachian tube. Upon the internal tympanic wall it divides. One branch anastomoses with the fibres of the carotid plexus through the *small deep petrosal*, forming the tympanic plexus; another nerve twig passes through a bony foramen in the tegmen tympani, to assist in forming the *small superficial petrosal* nerve which is the facial tributary to the otic ganglion; a third emerges from the cavity to join the *great superficial petrosal* nerve, which is derived from the facial, and unites with the *great deep petrosal* from the sympathetic to form the Vidian nerve, the posterior root of Meckel's ganglion.

---

* Archiv für Ohrenheilk., vol. iv, p. 290.

Briefly, we may describe this complex nervous anastomosis as follows: The glosso-pharyngeal, through its tympanic branch, anastomoses with branches from the carotid plexus, upon the internal wall of the middle ear, forming the tympanic plexus; from this plexus two branches are given off, one communicating with the otic ganglion, the other with Meckel's ganglion.

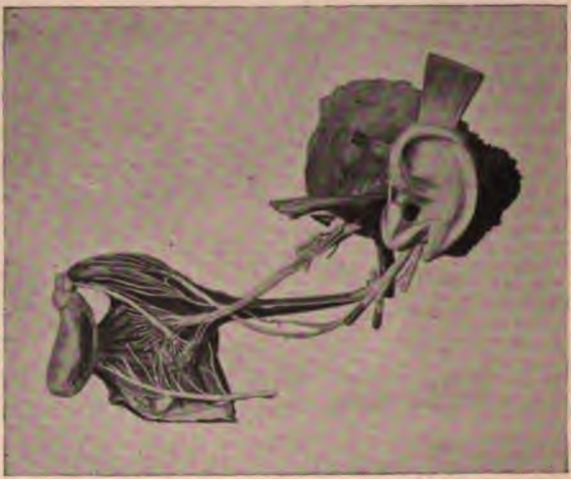


FIG. 20.—The nerves of the conducting mechanism, and their anastomotic branches.

We have yet to mention the chorda tympani, which, emerging from the aquæductus Fallopii above the pyramid, crosses the tympanic cavity from behind forward, passing between the long process of the incus and the manubrium of the malleus. It leaves the middle ear through a separate canal which lies close to the Glaserian fissure, and joins the lingual branch of the trigeminus.

It can not but be noticed how richly the conducting apparatus of the ear is supplied with nerves, especially in the deeper and more delicate parts. More will be said upon this subject in considering the physiology of the conducting mechanism, but the free anastomosis between the various nerves should be particularly borne in mind, for it is due to this fact that changes within the external or middle ear or Eustachian tube may give rise to remote symptoms, and that these regions may themselves be the seat of reflex disturbances.

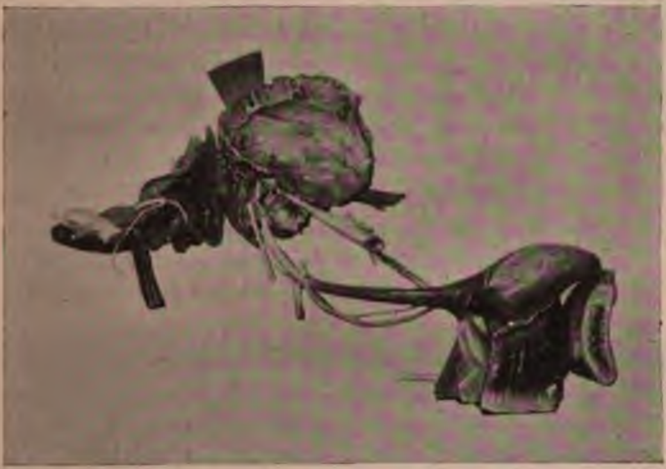


FIG. 21.—The nerve distribution within the tympanum.

II. THE RECEPTIVE MECHANISM.

We have now described that part of the apparatus of audition, concerned in the transmission of sonorous vibrations from without, to the point where they are brought into immediate relation with the end organ of the auditory nerve. Let us next consider the structures concerned in the interpretation of these sonorous vibrations.

For reasons already given, we include under this general term, not only the internal ear, but also the auditory nerve and its centers of origin, as well as the various avenues of communication with other centers, and with the corresponding nuclei of the opposite side and with the cortical area of audition in the brain.

For convenience of description, the course of the auditory nerve will be followed from the specialized end organ found in the labyrinth, inward toward its origin, rather than in the opposite direction, which would be more strictly correct from an anatomical point of view.

The internal ear comprises the osseous and membranous labyrinth, the former being a series of communicating chambers tunneled in the petrous portion of the temporal bone and filled with fluid, in which the membranous labyrinth is suspended. This latter structure consists of a series of membranous tubes, also filled with fluid, called the endolymph. They follow the general contour of the osseous passages in which they lie, but do not completely fill them, the intervening space being occupied by the perilymph.

The Bony Labyrinth (Fig. 22).—The bony labyrinth may be described as a central chamber in the petrous portion of the temporal bone, called the vestibule, from which various tortuous channels diverge. This central chamber is ovoid in shape, the vertical diameter being the greater and measuring about one fourth of an inch, while the short diameter is

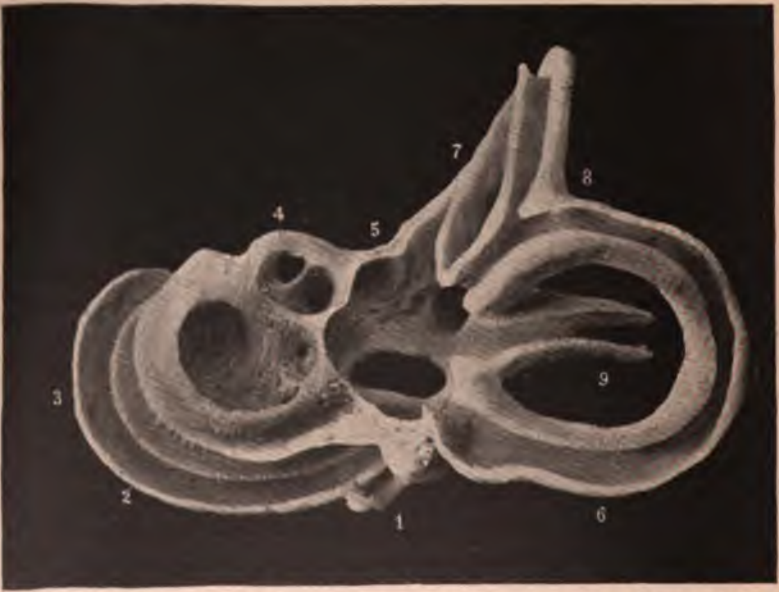


FIG. 22.—The bony labyrinth. (Rüdinger, Blake's translation.) 1, Round window; 2, Lamina spiralis ossea; 3, Osseous cochlear canal; 4, Floor of internal auditory meatus; 5, Vestibule; 6, 7, 8, 9, Semicircular canals.

about one fifth of an inch. On its outer wall it presents a kidney-shaped opening, which under normal conditions is closed by the foot plate of the stapes. The inner wall exhibits two fossæ, separated by a bony spine called the crista vestibuli. The anterior depression, which is occupied by the saccule, is the recessus sphericus; the posterior, lodging the utricle, is the recessus ellipticus. The posterior wall presents the openings of the three semicircular canals; these openings are five in number, two canals, the superior and posterior entering the vestibule by a common channel. The entrance to the cochlear canal takes the place of the anterior wall of the vestibule. On the inferior internal wall, close to the border of the recessus ellipticus, there is a small opening, the orifice of the aquæductus vestibuli. Through this channel the cavities of the membranous labyrinth communicate with the subdural space.

The *semicircular canals* are three in number, and are so disposed that the plane of each canal is perpendicular to that of the other two; they are denominated the superior, posterior, and external canals. The posterior lies in the vertical plane of the long axis of the petrous portion of the temporal bone. The superior is placed at right angles to this, and is also vertical, while the external canal lies in the horizontal plane. As the name implies, each of these bony passages bends upon itself to form a semicircle, the point of origin and termination being the vestibule. The superior and posterior canals terminate in this cavity by a common opening, but with this exception each communicates with the vestibule by two openings, one of which may be considered the source and the other the terminus. Where the outer extremity of the external canal enters the vestibule the lumen of the passage becomes dilated, forming what is known as an ampulla. The unjoined vestibular extremities of the posterior and superior canals are also ampullated.

The Cochlea.—The entrance of this passage lies at the anterior and inferior aspect of the vestibule. It consists of a bony tube coiled two and a half times about an osseous axis —the modiolus. From the modiolus a thin septum of bone —the lamina spiralis—made up of two thin bony plates, extends into the lumen of the tube, partially dividing it into two channels. This bony partition does not extend completely across the canal to the outer wall, the intervening space being bridged by a membranous septum, which completes the division of the cochlear tube. This fibrous septum is called the lamina spiralis membranacea. The lamina spiralis at its free border divides into a superior and inferior limbus. The space inclosed by this separation is called the sulcus laminæ spiralis. At the apex of the cochlea the partition which divides the canal into two distinct channels is incomplete; the termination of the septum is somewhat hook-shaped, forming the hamular process, while the passage of communication between the superior and inferior spaces is called the helicotrema. The terminal half-turn of the cochlea forms the cupola, and in this region the lamina spiralis ossea, just before its termination, is twisted upon itself in such a manner as to inclose a funnel-shaped space called the infundibulum.

The modiolus is traversed by numerous canals, the largest running through its axis and named the canalis centralis modioli, from which secondary channels diverge into the lamina. At the junction of the modiolus with the lamina a canal ascends spirally between the layers of this bony septum, passing to the very apex of the cochlea. This is called the canalis spiralis modioli. The lamina spiralis ossea, with the membranous lamina, divides the bony cochlea into two passages, as already stated. The lower is called the scala tympani, the upper the scala vestibuli. The modiolus and the lamina are so disposed that the scala tympani does not communicate with the vestibule, but leads into the tympanic cavity at the round window. In fact, we may consider the cochlear canal as beginning at the fenestra rotunda, at the inferior external angle of the vestibule, the wall at this point forming the modiolus. As the first turn passes forward and then upward from the round window, the contiguous walls of the tube and of the vestibule amalgamate and form a partition extending into the tube, which divides it into two channels, the upper of which communicates with the vestibule. The bony partition thus formed does not extend entirely across the tube, and the septum is completed by the membranous spiral lamina. Just beyond the round window in the floor of the scala tympani a narrow canal extends to the inferior surface of the petrous bone. This is the aquæductus cochleæ, and can be traced to the subarachnoid lymph space; it affords an avenue of communication between the perilymph and the intracranial lymph sac. After the lamina spiralis ossea separates into two thin plates of bone, each is continued as a membranous septum as far as the outer wall of the cochlea. Here, by their divergence, they inclose a triangular space, which extends from the round window to the apex of the cochlea, in a spiral direction ; this space, converted into a tube by the outer wall of the cochlea, is called the cochlear canal or scala media. Where the diverging septa join the outer bony wall of the cochlea the periosteum is thickened and richly supplied with blood vessels, especially where it joins the lower lamella, where it is called the ligamentum spirale.

That portion of the membranous septum which is continuous with the inferior lamella of the osseous spiral lamina passes outward in the same plane as the lamina spiralis ossea, and becomes the membrana basilaris. The upper leaflet forms an acute angle with this, and is called the membrane of Reissner.

The manner of formation and the course of the various channels having been described, we have next to consider the lining membrane.

The walls of the osseous canals and vestibule are covered by delicate fibrillated connective tissue rich in nuclear elements ; this is applied closely to the osseous walls, constituting the periosteum. Its surface is covered with flat endothelial cells. The lumen of the bony semicircular canals or perilymphatic space is traversed by delicate bands of the connective-tissue covering of the osseous walls, which pass to the outer wall of the membranous canals, thus dividing the perilymphatic space irregularly. At the point of attachment of the membranous canals to the walls of the passage their lining membrane is thickened.

The Membranous Labyrinth (Fig. 23).—The membranous labyrinth consists of a series of tubes, formed of delicate connective tissue, lying within the bony channels already described. The membranous simicircular canals terminate in the utricle, which lies in the recessus ellipticus vestibuli, while the membranous cochlea is joined to the saccule by a very narrow canal, called the canalis reuniens Hensenii. This entire series of tubes is filled with a clear fluid known as the endolymph. Thus far we have described two series of channels, containing fluid, terminating in somewhat spherical chambers—the utricle and saccule. The membranous cochlea terminates in a blind pouch (the lagena) at the apex of the bony passage in which it lies. From the adjacent aspects of the utricle and saccule a delicate canal is given off which coalesces into a common channel—the ductus endolymphaticus. This traverses the aquæductus vestibuli and terminates in a blind sac (the recessus of Cutogno) upon the posterior surface of the petrous bone beneath the dura. According to Rüdinger,* the endolymph may pass to the dural lymph spaces through this canal. The saccule and utricle lie upon the internal wall of the bony vestibule, but do not fill the cavity completely, considerable space being left between them and the outer wall. The intervening space is filled with perilymph, and is called the cisterna lymphatica. It is of practical importance to remember that the distance from the inner surface of the foot plate of the stapes to the opposite wall of the membranous labyrinth is about three millimetres, or one eighth of an inch. In the same manner the lumen of the bony cochlea

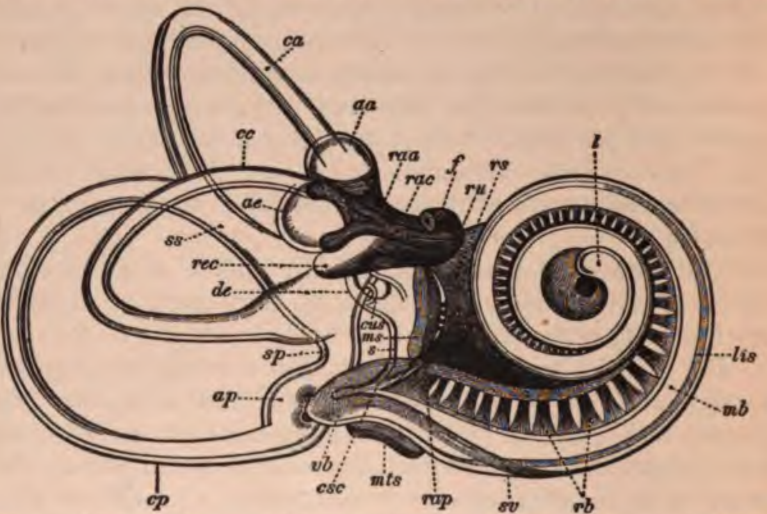


FIG. 23.—Adult membranous labyrinth (osmic-acid preparation). (Retzius.) *l*, Lagena; *lis*, Spiral ligament; *mb*, Basilar membrane; *sv*, Stria vascularis; *mts*, Membrana tympani secundaria; *csc*, Canalis reuniens; *s*, Lower end of saccule; *cus*, Canalis utriculo-saccularis; *de*, Ductus endolymphaticus; *sp*, Posterior utricular sinus; *rec*, Recessus utriculi; *aa*, *ae*, *ap*, Ampullæ of anterior, external, and posterior canals; *vb*, Vestibular *cul-de-sac*; *ca*, *cc*, *cp*, Semicircular canals; *ss*, Union of posterior and superior canals; *rb*, *rap*, *rs*, *ru*, *raa*, *rac*, Branches of auditory nerve to various portions of membranous labyrinth; *ms*, Macula acustica of saccule; *f*, Facial nerve.

---

* Arch. für Ohrenheilk., vol. xxvii, p. 222.

and semicircular canals is not completely filled by the contained membranous structures; these latter are attached to the bony walls along the line of their convexity, and the periosteum is thickened along this line. Additional support is afforded the semicircular canals by bands of connective tissue which pass from the outer wall of the membranous channel to the osseous walls.

Regarding the microscopical structure of the membranous labyrinth, it may be described as made up of a framework of connective tissue, the outer surface being covered by a reflection of the endothelial layer which lines the bony labyrinth. The lining of the irregular cavity is of much greater interest, since it constitutes the special end organ of the auditory nerve.

The Saccule and Utricle.—Upon the internal surface of the saccule and utricle, in the region corresponding to their attachment to the bony vestibular wall, there is a mound or papilla which encroaches somewhat upon the lumen of the cavity. This papilla is called the macula acustica, and is formed by the aggregation of the cells which form the lining of the space, the epithelium changing from the polygonal pavement variety to the cuboidal, and then to the cylindrical form as it approaches the region of the macula. The papilla itself is covered by a specialized epithelium, the cells appearing under two forms, either as ciliated or hair cells, or as supporting cells placed between those before named. The supporting cells have large nuclei, and are either cuboidal below near the base, sending a delicate process to the surface, or they are fusiform, the nucleus lying near the centre. They terminate in elongated processes, one of which lies upon the surface of the papilla, the other passing to the basement membrane.

The hair cells are elongated protoplasmic masses, each with an ovoid base, from which the body gradually tapers to a constricted portion called the neck, just below the superior extremity; above this, the cell again becomes broad. From the free extremity of each cell, ten to twelve ciliæ project into the cavity; these are called the auditory hairs. According to Kaiser,* whose description I have most closely followed here, the body of each hair cell is completely surrounded by a delicate envelope, formed by the expansion of the axis cylinder of a single nerve fibrilla, although the axis cylinder cannot be traced with certainty into the cell body. The surface of the macula acustica constitutes the membrana limitans; this is reticular in structure, and through its spaces the auditory hairs project. In hardened specimens the auditory hairs are usually matted together, and the macula appears to be covered by a finely fibrillated gelatinous substance, in which some of the ciliary processes can be made out. Lying between the ciliæ, upon the surface of the macula we find an aggregation of minute crystals—the otoliths—apparently imbedded in the structureless covering of the mound. The agglutination of the auditory hairs is probably due to changes effected in the endolymph by fluids used in hardening the specimens. The macula acustica of the utricle and saccule are identical in structure. In the ampullæ similar papillæ are found, and are here called the cristæ acusticæ. The cristæ acusticæ are smaller than the maculæ acusticæ, their hair cells are also less developed, and the individual ciliæ can not be made out. In hardened specimens the apex of the crista has the same structureless appearance as that of the macula, the homogeneous substance surmounting it being here called the cupula. The appearance is probably due to the action of the hardening fluids upon the endolymph. The membranous canals are lined with polygonal pavement epithelium, and present, at various portions of their course, a papillary structure. No nerve elements have been traced to the interior of the canals.

---

* Arch. für Ohrenheilk., vol. xxxii, p. 181.

The Membranous Cochlea or Scala Media.—This passage is joined to the saccule by the canalis reuniens Hensenii, and consists of a membranous tube, triangular on cross section, inclosed between the membrane of Reissner above, and the membrana basilaris below. Its outer wall is formed by the endothelial lining of the bony cochlea. At its lower extremity the canal terminates in a blind pouch at the round window, the cæcum vestibuli, the basilar membrane completely shutting it off from the vestibule. The superior blind extremity is called the lagena. The superior and inferior walls are formed by a continuation of the divergent lips of the osseous spiral lamina, each of which becomes membranous after the division of the bony partition into two plates, and extends to the opposite bony wall of the cochlea. The inferior membranous wall or floor is called the membrana basilaris. At the sulcus spiralis, the basilar membrane becomes much thickened, forming the limbus laminæ spiralis, or crista spiralis. This separates into two lips, the furrow thus formed being called the sulcus spiralis internus. This groove is lined with cuboidal epithelial cells which pass upward to the vestibular lip. The basilar membrane stretches from the tympanic lip of the crista spiralis to the spiral ligament; it is made up of tightly stretched transverse fibres, the length of the successive fibres increasing from the base of the cochlea to the apex. The tympanic surface of the membrana basilaris is covered with polygonal pavement epithelium continuous with the lining of the scala tympani.

The epithelium of the upper surface of the basilar membrane is cuboidal for a short distance beyond the sulcus spiralis internus; the cells then become successively columnar, and farther outward undergo certain changes (to be described later), as a result of which there appears to be a ridge along the surface of the basilar membrane. Closer inspection shows that this ridge is really a series of arches. Beyond this ridge the cells again become cuboidal. This longitudinal ridge, which is continuous along the central portion of the basilar membrane from the round window to the lagena, appears as a papilla in a vertical section of the cochlea, and is called the papilla acustica or zona tecta of the membrane; the outer portion is called the zona pectinata, and the inner the zona perforata. The epithelium of the zona perforata is cuboidal and pierced with nerve fibres which reach it by passing outward from between the lips of the osseous lamina. Where it joins the zona tecta the cells become columnar, and are called the inner supporting cells. Next to these is a single row of elongated cells terminating above in ciliæ; these are the inner hair-cells. Beyond the inner hair-cells lie the inner rods of Corti, which rise from the basilar membrane, and form, with the outer rods, an arch called Corti's arch.

This arch can be plainly seen in microscopic specimens (see Fig. 24) when the sections are made perpendicular to the basilar membrane, since it extends throughout the entire length of the cochlea. These successive arches form a closed passage or tunnel from the lowest portion of the cochlea to its apex, covering over the portion of the membrana basilaris between the bases of the inner and outer rods. The inner rods arise from a broad base and extend upward and outward at an angle of about sixty degrees. Immediately above the base the cells become narrow, transparent, and structureless; they terminate in a club-shaped upper extremity or head, which is hollowed out on its outer aspect for the reception of a corresponding rounded process upon the outer rods. From the head of each inner rod a process extends horizontally inward, separating the adjacent hair cells. The outer rods are more numerous than the inner, and make an angle of about forty-five degrees with the basilar membrane; they are longer than the inner rods, but of the same shape, and their club-shaped heads fit into the articular process upon the outer surface of the head of the corresponding inner rod. The outer cells being greater in number than the inner, each member of the latter series supports two or three of the external fibres of Corti. Beyond the outer rods there are found from three to five rows of hair-cells, of the same general structure as those observed in the zona perforata. They rise, however, almost perpendicularly from the basilar membrane, thus leaving a space between the outer rods and the inner row of hair cells, known as Nuel's space. The rows of outer hair-cells are separated from each other by the cells of Deiters. These are broad at their base, but narrow as they approach the surface, and are marked along their inner border by a bright line which runs the entire length of the cell from the upper to the lower extremity. The upper extremity of this bright line, called the supporting fibre, terminates in a delicate lamella or phalanx; the contiguous phalanges form by their

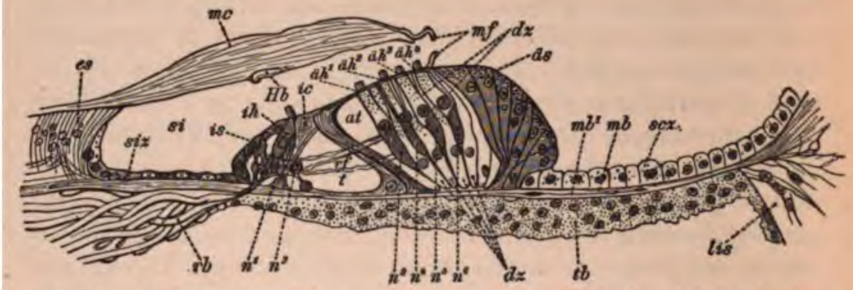


FIG. 24.—Vertical section of the membranous cochlea. (Retzius.) *es*, Limbus laminæ spiralis; *mc*, Membrane of Corti; *si*, Sulcus internus; *is*, Inner supporting cells; *ic*, Inner rods; *ih*, Inner hair-cells; $\ddot{a}h^1$–$\ddot{a}h^4$, Outer hair-cells; *dz*, Deiters's cells; *äs*, Supporting cells of Hensen; *rb*, Nerve fibres; n^1–n^6, *rf*, Nerve fibres to hair-cells; *at*, Nuel's space; *mb*, mb^1, *tb*, Basilar membrane; *lis*, Spiral ligament.

union a reticular membrane, through the interstices of which the outer hair-cells project. Beyond the cells of Deiters the epithelium again becomes columnar, forming the outer supporting cells, beyond which it resumes gradually the form found in the zona pectinata.

The membrana reticularis is formed by the union of the phalanges of the supporting fibres of Deiters's cells; its outer limit is poorly defined. It passes inward from the inner row of Deiters's cells to the summit of Corti's arch, to which it is attached.

The Membrane of Corti, or Membrana Tectoria.—This is a gelatinous membrane arising from the upper border of the sulcus spiralis internus, just below the attachment of Reissner's membrane, and extending outward, over the papilla acustica, beyond the outer row of Deiters's cells; it is intimately connected with the hair-cells, but in exactly what manner is still a mooted question. The hair cells are supposed to be the specialized end organ of the cochlear nerve; the nerve fibres pass through the zona perforata as naked axis cylinders, and have been traced by Katz * to the interior of the inner hair cells. Delicate fibrillæ also cross beneath the arch of Corti, and have been traced to the outer of Deiters's cells and to the outer hair cells which they probably enter, although this is not certain.

Having described the peripheral termination of the auditory nerve, we will next follow its fibres backward to the main trunk.

From the cochlear hair-cells the filaments pass inward between the layers of the osseous spiral lamina, resume their medullated layer, and unite to form the cochlear branch of the auditory nerve in the tubulus centralis modioli. Where the fibres of distribution radiate from the central trunk within the modiolus a ganglionic enlargement is found, called the spiral ganglion. From the cristæ acusticæ and maculæ acusticæ the nerve filaments pass through minute foramina in the walls of the bony labyrinth. The nerve filaments unite to form the vestibular branches of the auditory nerve, the fibres from the saccule forming the inner branch, those from the utricle and ampulla of the external and superior canals the superior branch, and those from the ampulla of the posterior canal the inferior branch. These foramina constitute the macula cribrosa of the fovea spherica, and fovea elliptica.

---

* Arch. für Ohrenheilk, vol. xxix, p. 54.

The Blood Supply of the Labyrinth (Plate V).—*The Arteries.*—The blood supply is derived from the internal auditory artery, a branch of the basilar. The artery accompanies the auditory nerve to the labyrinth, where it divides into two branches, the one supplying the vestibule and semicircular canals, the other following the cochlear branch of the nerve to the cochlea, where minute vessels pass outward, forming an arterial plexus for the supply of the membranous cochlea. The minute vessels radiate from the larger arterial twigs toward the outer labyrinthine walls of the scala vestibuli and scala tympani, but are most prominent in the walls of the scala vestibuli.

The Veins.—The veins follow the same general course as the arteries, the smaller branches uniting to form three main channels—the vein of the cochlear aqueduct, the vein of the aquæductus vestibuli, and occasionally a third vessel is found, the internal auditory vein, although this is the least constant branch.

The vein of the aquæductus cochleæ passes through the cochlear aqueduct to the internal jugular. The vestibular vein joins the superior petrosal sinus, leaving the labyrinth through the aquæductus vestibuli, while the internal auditory vein accompanies the artery of the same name and empties into either the transverse or inferior petrosal sinus.

The terminal branches of the venous channels anastomose freely with one another, forming spiral plexuses or loops. In general, it may be said that the blood current enters the labyrinth upon one aspect, and, instead of forming a complete circuit and finding an exit in the same region, passes out on the opposite side of the labyrinthine cavity, the chief avenue of venous discharge from the cochlea being the vein of the cochlear aqueduct.

Boettecher[*] describes a capillary twig running along the tympanic surface of the basilar membrane under the arch of Corti, which he calls the vas spirale of the cochlea. Its existence has been denied by Berthold,[†] and Siebenmann.[‡] Eichler[#]

---

[*] Arch. für Ohrenheilk, vol. xxiv, p. 1.

[†] Schwartze's Handb. der Ohrenheilk., 1893, vol. i, p. 711.

[‡] Arch. für Ohrenheilk., vol. xxxv, p. 115.

[#] Abhandl. d. math. phys. Klasse der k. sach. Gesell. der Wissenscnaft des physiolog. Inst. zu Leipzig, 1892, vol. xviii, No. 5, p. 311.

space being bridged by a membranous septum, which completes the division of the cochlear tube. This fibrous septum is called the lamina spiralis membranacea. The lamina spiralis at its free border divides into a superior and inferior limbus. The space inclosed by this separation is called the sulcus laminæ spiralis. At the apex of the cochlea the partition which divides the canal into two distinct channels is incomplete; the termination of the septum is somewhat hook-shaped, forming the hamular process, while the passage of communication between the superior and inferior spaces is called the helicotrema. The terminal half-turn of the cochlea forms the cupola, and in this region the lamina spiralis ossea, just before its termination, is twisted upon itself in such a manner as to inclose a funnel-shaped space called the infundibulum.

The modiolus is traversed by numerous canals, the largest running through its axis and named the canalis centralis modioli, from which secondary channels diverge into the lamina. At the junction of the modiolus with the lamina a canal ascends spirally between the layers of this bony septum, passing to the very apex of the cochlea. This is called the canalis spiralis modioli. The lamina spiralis ossea, with the membranous lamina, divides the bony cochlea into two passages, as already stated. The lower is called the scala tympani, the upper the scala vestibuli. The modiolus and the lamina are so disposed that the scala tympani does not communicate with the vestibule, but leads into the tympanic cavity at the round window. In fact, we may consider the cochlear canal as beginning at the fenestra rotunda, at the inferior external angle of the vestibule, the wall at this point forming the modiolus. As the first turn passes forward and then upward from the round window, the contiguous walls of the tube and of the vestibule amalgamate and form a partition extending into the tube, which divides it into two channels, the upper of which communicates with the vestibule. The bony partition thus formed does not extend entirely across the tube, and the septum is completed by the membranous spiral lamina. Just beyond the round window in the floor of the scala tympani a narrow canal extends to the inferior surface of the petrous bone. This is the aquæductus cochleæ, and can be traced to the subarachnoid lymph space; it affords an avenue of communication between the perilymph and the intracranial lymph sac. After the lamina spiralis ossea separates into two thin plates of bone, each is continued as a membranous septum as far as the outer wall of the cochlea. Here, by their divergence, they inclose a triangular space, which extends from the round window to the apex of the cochlea, in a spiral direction; this space, converted into a tube by the outer wall of the cochlea, is called the cochlear canal or scala media. Where the diverging septa join the outer bony wall of the cochlea the periosteum is thickened and richly supplied with blood vessels, especially where it joins the lower lamella, where it is called the ligamentum spirale.

That portion of the membranous septum which is continuous with the inferior lamella of the osseous spiral lamina passes outward in the same plane as the lamina spiralis ossea, and becomes the membrana basilaris. The upper leaflet forms an acute angle with this, and is called the membrane of Reissner.

The manner of formation and the course of the various channels having been described, we have next to consider the lining membrane.

The walls of the osseous canals and vestibule are covered by delicate fibrillated connective tissue rich in nuclear elements; this is applied closely to the osseous walls, constituting the periosteum. Its surface is covered with flat endothelial cells. The lumen of the bony semicircular canals or perilymphatic space is traversed by delicate bands of the connective-tissue covering of the osseous walls, which pass to the outer wall of the membranous canals, thus dividing the perilymphatic space irregularly. At the point of attachment of the membranous canals to the walls of the passage their lining membrane is thickened.

The Membranous Labyrinth (Fig. 23).—The membranous labyrinth consists of a series of tubes, formed of delicate connective tissue, lying within the bony channels already described. The membranous simicircular canals terminate in the utricle, which lies in the recessus ellipticus vestibuli, while the membranous cochlea is joined to the saccule by a very narrow canal, called the canalis reuniens Hensenii. This entire series of tubes is filled with a clear fluid known as the endolymph. Thus far we have described two series of channels, containing fluid, terminating in somewhat spherical chambers—the utricle and saccule. The membranous cochlea terminates in the corpora quadrigemina through the fillet, a small bundle passes to the spinal cord, a third passes to the region of the abducens nucleus and communicates with it, while a fourth bundle of fibres passes to the cerebrum. From the tuberculum acusticum a small bundle of fibres crosses the median line to the opposite fillet, uniting with those which pass between the olivary body and the posterior of the corpora quadrigemina of this side.

To recapitulate briefly, most of the fibres from either cochlear nerve pass to the opposite side of the brain through the trapezoid bodies to the opposite olive, then through the fillet to the posterior quadrigeminal body, accompanied by a few filaments from the tuberculum acusticum. A small proportion of the fibres in the cochlear nerve in question do not cross, but pass to the cortical centres of the corresponding side of the brain through the olive of this side. The course of the fibres from the corpora quadrigemina has not been definitely made out, although the position of the nuclei in the medulla and the decussation of the fibres has been verified by physiological experiment. After entering the corpora quadrigemina the fibres are supposed to pass to the posterior third of the internal capsule, and from there to the first and second temporal convolutions, this being the auditory centre in the cortex according to the most recent investigations.

The Vestibular Nerve.—The vestibular nerve arises from the internal or dorsal nucleus, close to the vagus centre, but superficial to this. Branches originating in this collection of nerve cells cross the raphé, embracing in their course the nucleus of the sixth nerve and pass to the cerebral cortex, although the exact course which they follow is undetermined. A large fasciculus extends to the cerebellum, passing first through the pons, then the vermis, and finally terminates in the corresponding cerebellar hemisphere and in that of the opposite side. The dorsal nucleus communicates with the spinal cord through a fasciculus which passes downward and inward between the olivary bodies.

Besides the cochlear and vestibular roots, the auditory trunk contains a bundle of fibres which emerge between the roots already described. These arise from an aggregation of cells, called Deiters's cells, lying in the medulla between the anterior nucleus and the olivary body. The branches of communication with the other nuclei of the eighth nerve and with other cerebral centres are undetermined.

We thus appreciate the complexity of the central portion of the acoustic apparatus, and may realize what manifold causes may exist for impairment or perversion of function. We must bear in mind that any disturbance of audition of nervous origin may be variously located at any point between the cochlea, which represents the end organ of the auditory nerve, and the first and second temporal convolutions of the cerebrum, which represent the cortical auditory area. The fibres from the cochlea of either side, according to our description, pass through the cochlear nerve to the ventral nucleus and to the tuberculum acusticum, most of the fibres passing to the superior olive of the opposite side through the corpora trapezoides, and then to the corresponding posterior quadrigeminal body through the fillet; thence to the posterior third of the internal capsule, and thence to the first and second temporal convolutions. A smaller collection of fibres from the anterior or ventral nucleus passes to the olive of the same side, through the trapezoid body and to the cortical area of this side, following a course similar to that pursued by the fibres from the opposite olivary body; from this olivary body other fibres pass to the cerebellum, to the spinal cord, and to the abducens nucleus.

The portion of the cochlear nerve terminating in the tuberculum acusticum sends a few decussating fibres to the opposite fillet, its only other communication being that afforded by its immediate proximity to the anterior nucleus.

The vestibular nerve twigs amalgamate into a trunk, which terminates in the internal or dorsal nucleus, from which fibres pass to the spinal cord, to the cerebellar hemisphere of the same, and to that of the opposite side, and probably to the opposite cerebral hemisphere. The communication with the cerebellum is the most extensive, and this portion of the brain constitutes the important terminus of the vestibular branch of the auditory trunk.

CHAPTER II.

THE PHYSIOLOGY OF THE EAR.

In order to understand the manner by which sound perception is effected, it will be well to recall the physical principles involved in sound production and transmission.

Sound is a mode of motion produced by the vibration of matter. Vibrations are transmitted to the organ of hearing through any elastic medium. If the vibrations succeed each other at regular intervals and with sufficient rapidity they affect the ear collectively, rather than as separate impulses, and produce what is known as a musical sound. If the impulses are irregularly repeated, or if the interval between each is of considerable duration, the impression constitutes a noise, each act of transmutation of energy into motion producing an effect upon the receptive centres. When the impulses follow each other at a rate of less than sixteen per second they are observed singly; but if at a greater rapidity, the sound becomes musical and continuous. According as the rate of vibration is slow or rapid, the note is of low or high pitch, until finally the vibrations follow each other so rapidly that the ear no longer appreciates them. From this we see that the ear possesses certain limits of perception for musical sounds, between which all regularly recurring vibrations impress the organ in a certain definite way. These limits are called the tone limits of the ear, and range from about sixteen double vibrations per second to thirty-two thousand five hundred double vibrations per second.

It will be understood that the figures given represent the average limits only, in certain instances the lower limit being somewhat below the one given, while the upper limit may be higher. Quite distinct from the pitch of a note is its intensity or loudness; this depends upon the amplitude or extent of each individual vibration. Although depending upon entirely different physical conditions, pitch and intensity are, to a certain extent, related, since, as the vibrations increase in number, the space traversed during each unit of time by a vibrating body must be less. We quite unconsciously prove the truth of this statement when we remember that we associate loud sounds with high, shrill notes, while the reverse is true of tones of the lower portion of the register. In other words a given force will produce a more intense sound if it acts upon a body in such a manner as to produce molecular vibrations rather than vibrations *en masse*.

For convenience in recording the various rates of vibration, a tuning fork, or other sounding body making sixteen double vibrations per second (V. D.), may be called C^{-2}; one making double this number of vibrations would be called C^{-1}; the two notes differing from each other by an octave. This division of the musical scale, should be remembered as indicating that when two musical notes differ from each other by an octave the rates of vibration are as two to one.

In the above we have considered simple vibrations only; but it is to be remembered that a note is seldom heard absolutely pure, but is accompanied by tones of higher pitch in the musical scale. These are called overtones, and they modify the character of the fundamental note. These overtones give the individuality or quality to the various instruments used in an orchestra, and enable us to distinguish whether a given note is sounded upon a wind or string instrument. These harmonics are much more prominent in the lower divisions of the scale, and, as will be seen when we come to speak of the functional examination of the ear, are to be borne in mind, since by their perception, in place of the fundamental tone erroneous deductions may be drawn.

Sound waves are propagated in any medium surrounding a vibrating body at rates varying with the density of the medium. The rate of transmission is greater in solids and liquids than in gases. In gaseous media the rate of transmission of sound is in inverse proportion to the density of the gas.

We are now prepared to study the action of the transmitting mechanism of the ear from a physiological standpoint, bearing in mind that this portion of the organ subserves the purpose simply of conducting aërial vibrations to the end organ of the auditory nerve, which analyzes them, so that each individual note produces certain specific effects upon the re-

LANE LIBRARY

ceptive centres. We next consider the use of the various portions of the conducting mechanism.

The Auricle.—The auricle, representing the open end of a funnel, collects aërial vibrations and directs them into the external meatus. Its angle of attachment to the skull and the variations in contour encountered in different individuals no doubt exert slight influences upon sound perception, but this fact may be practically disregarded in man, and the auricle may be removed without seriously interfering with the function of audition. Among the lower animals the auricle plays a very important part in the sense of hearing, being movable, and capable of assuming various positions from volition or reflex action in order better to collect aërial vibrations from different points.

The External Meatus.—The external meatus constitutes a tube through which the sonorous impulses are conveyed inward toward the labyrinth with undiminished intensity. Even if this tube is very small in its deep portion, the function of audition may be but little impaired, the oscillations in the column of air being transmitted with undiminished intensity. If the narrowing takes place at the orifice of the meatus, acuteness of hearing is much diminished. This condition is occasionally found in the aged in whom the tissues have undergone a certain amount of atrophy, resulting in the collapse of the superior wall of the cartilaginous meatus to such an extent that it lies in contact with the inferior wall, completely occluding the canal. Occasionally the tragus is abnormally developed, and projects backward over the mouth of the canal in such a manner as to offer an obstruction to the entrance of the sound waves. This condition also renders the hearing less acute.

As mentioned in a previous chapter, the external auditory meatus is not directed horizontally inward, but the cartilaginous and osseous portions join at an obtuse angle both in the horizontal and vertical plane. The cartilaginous canal is directed upward, backward, and inward, while the osseous portion extends forward, downward, and inward. Where the cartilaginous meatus joins the auricle the posterior wall presents a deep fossa or depression, and the antero-inferior wall of the bony canal close to the membrana tympani exhibits a somewhat similar feature. In the cartilaginous canal this excavated portion acts with the auricle to collect the waves of sound and direct them into the meatus, while by the hollowing out of the antero-inferior wall of the deeper portion of the meatus, the surface presented is parabolic, from which reflected waves are directed almost perpendicularly upon the drum membrane. Since the meatus is a closed tube it necessarily possesses a fundamental note, which, according to Gad,* lies in the fourth accentuated octave, representing about 4,056 V. S. The effect of the resonant action of the canal upon audition is practically inappreciable, its primary note lying beyond the limit of the conversational voice. When, however, the middle ear is filled with fluid or the drum membrane is much thickened, the resonant action of the canal becomes more marked and is demonstrable. This is also true when the meatus is closed with the finger or occluded by a foreign body, the imprisoned column of air under these conditions being set in vibration through the medium of the cranial bones.

The Membrana Tympani.—This structure acts at once as a protective septum to the parts lying within the middle ear, and as a mechanical device for the reception of sonorous vibrations, which are then transmitted through the agency of the ossicular chain to the perilymph, being brought into relation with this fluid by the foot plate of the stapes. The advantage gained depends upon the relatively large surface which the membrana tympani presents in comparison with that of the foot plate of the stapes. Any impluse, therefore, acting upon the membrane is transmitted to the stapes, at which point its power is much augmented. The drum membrane is usually spoken of as a tense fibrous septum, and hence should possess a fundamental note peculiar to itself. The fact is, however, that, owing to the arrangement of the radiating and circular fibres of the lamina propria, its mode of attachment to the malleus handle, its oblique position, and the relaxed condition of its upper portion—the membrana flaccida—its fundamental note exercises but an unimportant influence upon the sense of hearing. It therefore transmits notes, varying greatly in pitch, with equal facility and without the accentuation of any particular tone, a phenomenon which would necessarily occur if the membrane itself possessed a fundamental note. This impartial transmission of sound waves which impinge upon it, without reference to their pitch depends chiefly upon the disposition of the circular and radiating fibres in its connective-tissue layer. The circular fibres serve to obliterate any resonant action which might result from the radiating fibres being thrown into sympathetic vibration. In the same way the handle of the malleus aids in cutting off the overtones, acting as a load upon the vibrating membrane and preventing the accentuation of any harmonic. The umbilication of this diaphragm at the umbo possesses a mechanical advantage, a force acting upon it being increased in intensity as it is transmitted to the malleus handle, while the distance traversed by the manubrium is correspondingly diminished.

---

* Schwartze, Handb. der Ohrenheilk., Leipzig, 1892, vol. i, p. 338.

The Ossicular Chain.—The alternate conditions of condensation and rarefaction brought about by a sounding body are transmitted to the labyrinthine structures, after impact against the drum membrane, through the ossicular chain. The outer member of this chain, the malleus, is attached to the membrana in the manner already described, while the innermost ossicle, the stapes, is in contact with the labyrinthine fluid at the oval window. Helmholtz * has shown, from the physical laws governing the transmission of sonorous vibrations, as the dimensions of the ossicles are so minute in comparison with the length of the waves which they transmit, that they may be considered as acting *en masse*—that is, each component of the chain acts as a single oscillating particle of infinitesimal dimensions, rather than as a solid body the molecules of which are in a state of vibration. Viewed in this manner, we have to deal with a system of levers through which a force applied at the tip of the malleus acts upon the stapes with increased energy, but with a corresponding diminution in the space traversed in a unit of time. As the result of experiment, the same author † found that any force acting upon the tip of the manubrium was augmented one and a half times at the incudo-stapedial articulation, the extent through which the tip of the long process of the incus moved being diminished two thirds.

The preceding remarks regarding the lever-like action of the ossicles refers only to forces tending to displace the malleus inward. It will be remembered that in describing the ligaments of the tympanum, it was stated that the anterior and posterior ligaments constituted the axis band of the malleus, this bone being supported at their points of insertion into its neck, and rotating about an imaginary line passing through these points and the tympanic attachments of the ligaments as an axis. The peculiar structure of the malleo-incudal articulation must also be borne in mind, the articular surface of the head of the malleus being in contact with the saddle-shaped articular surface of the incus. This articular surface is provided with a toothlike projection, so that whenever the manubrium of the malleus moves inward, with a consequent outward movement of the head, this motion is transmitted to the incus, and by this ossicle conveyed to the stapes. If, however, the tip of the manubrium is drawn outward, the toothlike process of the incus no longer engages the malleus, and the articular surfaces of the ossicles become separated. From this it follows that the stapes is but slightly displaced outward under these conditions. The practical importance of this will be seen at once when we remember how frequently the tympanic cavity is suddenly filled with air, either by accident or design, causing an extensive outward displacement of the membrana tympani. If the articular surfaces remained in contact under these conditions the effect would be to draw the stapes from the oval window. The long arm of the lever above described extends from the tip of the manubrium to the short process of the incus, while the point of transmission of force to the stapes lies in this line at the tip of the long process of the incus. The relative lengths of these two arms is in proportion of three to two, and the mechanical advantage gained is in the same ratio. The movement of the stapes is not directly inward, but rather in an oblique plane, the ossicle being rotated about its lower and posterior border. Motion in this oblique plane results not only from the peculiar position of the oval window, but also from the manner in which the incus is fixed to the tympanic wall, an inward excursion of the malleus carrying the long process upward and inward at the same time. The obliquity of the plane in which the ossicles are placed causes a slight movement forward in addition to the displacement described, the resultant motion imparted to the stapes being a rotation about its posterior and inferior borders. The capsular ligament of the malleo-incudal articulation plays an important part in the proper performance of the function of this joint. If this ligament is relaxed, the articular surface of the malleus, instead of being held closely against the corresponding surface of the incus and engaging the tooth-shaped process of the articular facet, is drawn away from the saddle-shaped articular surface of the incus, and causes but slight movement of the ossicle. This condition would interfere particularly with the transmission of those notes, the wave length of which was relatively considerable—in other words, the lower notes of the register. Too great tension of the capsular ligament interferes with free oscillation of the ossicular chain, and consequently with the proper transmission of sound waves, particularly those of low pitch. High notes, demanding but little displacement of the transmitting mechanism, are relatively less interfered with by anomalies in the tension of the tympanic ligaments.

---

* *Op. cit.*, p. 12.

† *Op. cit.*, p. 46.

It is interesting to note here the experiments of Politzer * regarding the effect produced by notes of various pitch upon the excursions of the ossicular chain. It was demonstrated that the oscillations of the ossicles were less extensive for very low notes than for those of the middle portion of the scale. When the pitch was very high, however, the amplitude of the ossicular vibrations was again diminished. The weighting of the ossicular chain interfered with the transmission of low-pitched sounds, while the higher ones were transmitted practically without interference. As stated above, although pitch depends upon the rate of vibration and intensity upon the extent of each oscillation, a certain relation must exist between them, as is proved by the well-known fact to which Gad † calls attention—that of two notes sounded with the same intensity, the higher will seem the louder. The importance of these circumstances can not be overestimated in their bearing upon pathological conditions of the conducting apparatus, since the result of clinical observation agrees with that of physiological experiment, showing that in affections of the transmitting mechanism alone, the impairment of function occurs first for sounds of very low pitch, the upper notes being transmitted with a fair degree of accuracy.

---

* Archiv für Ohrenheilk., vol. vi, p. 35.

† Schwartze, Handb. der Ohren., Leipzig, 1892, vol. i, p. 336.

The Tympanic Muscles.—We have considered above the part played by the ossicles alone, without regard to the action of any muscles which might modify their response to aërial vibrations. It is necessary, however, to bear in mind that, in addition to their ligamentous supports, their action is modified by two muscles—the tensor tympani and the stapedius. The anatomical characteristics of these have already been described.

The tensor tympani muscle, acting alone, would tend to draw the ossicles inward and upward, crowding their articular surfaces together and forcing the foot plate of the stapes into the oval window. This displacement would of necessity render the membrana tympani more tense; hence the name of the muscle, although its action in this direction is of but little practical importance.

The action of the stapedius is antagonistic to that of the muscle just described, since by its contraction the stapes is drawn out of the oval window by rotating upon the posterior margin of the foot plate, with the effect of reducing the tension of the labyrinthine fluid. It is probable that one of the chief uses of these muscles is to protect the labyrinth from the injurious effects of loud sounds, or of the sudden condensation of air in the meatus from any cause. Since they act in opposite directions, they increase the elasticity of the ossicular chain, the one guarding the labyrinth from sudden pressure from without, while the other, by crowding the ossicula together, militates against any outward displacement of the ossicles from any increase in intratympanic pressure. One value of this action is to guard the capsular ligament of the malleo-incudal articulation, the fibres of which would soon become stretched by repeated condensations of air in the tympanic cavity if it were compelled to sustain the entire pressure.

The Muscles of the Eustachian Tube.—In order that the membrana tympani may act simply as a transmitter and collector of aërial vibrations of various lengths, it is essential that its normal tension shall not be interfered with. An absolutely constant tension of this membrane can exist only when the atmospheric pressure is the same on either side. To preserve this equilibrium, the cavity of the tympanum, under normal conditions communicates freely with the outer world through the Eustachian tube. Owing to the fact that the anterior and inferior walls of the membranous portion of the passage are formed almost entirely of fibrous tissue, the antero-posterior walls are in contact, except along the roof, where the patency is preserved by the hook-shaped process of the cartilaginous plate. Although the physical conditions admit of the canal remaining patent in this situation, it is probable that the mucous membrane lining the passage is so loosely applied, that even here the lumen is practically obliterated when the parts are at rest, but that slight changes in pressure suffice to render the tube permeable in this portion. This is particularly true if the intratympanic pressure is increased, as air passes more easily from the tympanum through the tube than in the opposite direction. It is comparatively unimportant whether in certain cases the canal is patent while the parts are at rest. Since the aëration of the tympanum is accomplished through the action of its attached muscles, the part played by them in audition is one of great importance. It will be remembered that the tensor palati and the levator palati are in relation with the fibro-cartilaginous portion of the Eustachian passage, the former arising in part from its anterior wall, while the latter passes beneath the membranous floor along the inferior border of the posterior cartilaginous wall. Contraction of these muscles increases the caliber of the tube, the tensor drawing the anterior wall and the cartilaginous hook forward, while the belly of the levator is augmented in volume during contraction and presses the inferior and posterior walls upward, diminishing the diameter of the canal from above downward, but making it more patent. As both of these muscles are brought into play during the act of deglutition, the removal of the air within the middle ear must of necessity take place so frequently that the equilibrium of the membrana tympani is not disturbed. Temporary variations in pressure are undoubtedly compensated for by the action of the stapedius and tensor tympani muscles. When, owing to atrophy of the tubal muscles or to obstruction of the lumen of the canal from swelling of the lining membrane or from the presence of secretion, the passage remains closed for a considerable period, rarefaction of the air within the tympanum is the result. This is brought about by the absorption of air into the blood circulating in the lining membrane of the middle ear, and by the greater facility with which the air passes from the tympanum than in the opposite direction. This reduction in pressure within the middle ear allows the membrana tympani and attached ossicular chain to be forced inward by the pressure of the atmosphere, crowding the stapes into the oval window.

The Labyrinth.—The physiology of the labyrinth divides itself into an investigation of the function of the vestibule, the cochlea and the semicircular canals.

The Cochlea.—The cochlea is that part of the internal ear specialized for the analysis of sonorous vibrations. Through its agency each component of any complex sound affects one portion of the terminal fibres of the auditory nerve. These various stimuli are again combined in the higher nerve centres, and are interpreted as characteristic of some particular vibrating body, and hence from education enable us to judge of the conditions under which they were produced. To effect this separation of the complex aërial vibrations the undulations are transmitted by the conducting mechanism to a column of fluid, the perilymph. Recollecting the anatomy of the parts, it will be remembered that the cochlear perilymphatic space is divided into two channels lying one above the other, communicating at the apex of the spiral by a narrow passage, the helicotrema, and separated from each other by a septum which is partially osseous and in part membranous. The membranous portion incloses between its two layers a channel, triangular on cross-section, the membranous cochlea. This canal is an elongated blind pouch, and is filled with endolymph in which float the ultimate fibres of the auditory nerve.

The upper cochlear canal communicates with the vestibule, while the lower is shut off from the middle ear by the membrane of the round window. The membranous cochlea terminates at its superior extremity as a blind sac, while below it joins the saccule. The floor of this membranous tube begins at the upper part of the round window. The perilymphatic space through the aqueductus cochleæ communicates with the subarachnoid lymph space, while the endolymphatic channel, through the aqueductus vestibuli, opens into a sac between the layers of the dura mater. The probability of the communication between this dural pouch and the lymph channels of the dura has already been discussed.

Aërial vibrations communicated to the stapes produce a fluid wave in the perilymph, each inward excursion of the ossicle pushing the column of fluid before it through the scala vestibuli, thence through the helicotrema, and finally through the scala tympani to the round window, the membrane of which is pushed outward into the tympanum to compensate for the inward motion at the vestibular opening. Since the labyrinthine walls are rigid in every other situation, and from the well-known physical law that fluids are incompressible, this motion of the perilymph is impossible unless the membrane of the fenestra rotunda is elastic. The elastic partition separating these two channels modifies to an extent the course taken by this wave in the perilymphatic fluid. This septum, consisting of two layers, the space between being filled with fluid of the same density as the perilymph, permits of the transmission of the wave motion from the upper to the lower channel without necessitating its passage through the helicotrema. It is evident that the structures within the membranous cochlea must suffer some disturbance of equilibrium from the passage of this fluid wave. An impulse causing the inward motion of the stapes is communicated to the perilymph, which in turn exerts a pressure upon the basilar membrane; this elastic septum yields to the pressure in localities varying according to the pitch (or rate of vibration) of the particular note sounded. The depression of the basilar membrane at any given point causes a change in position in the structures resting upon it: these, it will be remembered, are the hair-cells and the rods of Corti. It is probable that the hair-cells, by the friction of their ciliary processes against the reticular membrane or against the rods of Corti, transmit these impulses through the nerve filaments which they contain, to the receptive centres of the brain. Since the endolymph and perilymph are under equal pressure, a fact which has been proved by the investigations of Ostmann,* it follows that all vibrations of the perilymph will not pass the entire length of the scala vestibuli and through the helicotrema before exciting similar waves in the fluid of the scala tympani, but will pass directly through the two layers of the membranous spiral lamina at any point where the resistance is less than that which must be overcome by the passage of the wave through the helicotrema. The fact that the diameter of this communicating channel is much less than that of either the scala vestibuli or the scala tympani increases the resistance in this direction and favors the passage of the wave through the elastic septum dividing the scalæ. The inferior lamella of this partition is the membrana basilaris, a tissue calculated from its structure to be easily affected by changes in pressure. Investigation shows that the parallel fibres of the membrane are shortest in the lowest part of the canal, and gradually increase in length as the spiral ascends. The shorter fibres at the base of the cochlea will yield to the pressure caused by vibrations of short wave length, or those concerned in the production of the highest notes of the scale, while the slower oscillations of the low notes will travel toward the apex of the cochlea before displacing the basilar membrane. Anatomical structure and physical laws render it probable, therefore, that the lowest turn of the cochlea is concerned in the perception of the high notes of the scale, while the upper turns serve for the recognition of the deeper sounds. These deductions have been confirmed by the physiological experiments of Baginsky.*

---

* Arch. für Ohrenheilk, vol. xxxiv, p. 35.

It seems probable that the basilar membrane is the portion of the auditory apparatus designed for the analysis and perception of musical notes as originally suggested by Hensen; and that the rods of Corti are not directly concerned in this process, as Helmholtz at first believed.

It is quite probable that these rods serve to damp the vibrations of the membrana basilaris, and to restrict them to limited portions for individual notes. The fibres of the basilar membrane vary in length from .041 millimetre at the base of the cochlea, to .495 millimetre at the apex. In number they vary from 13,000 to 20,000. It is evident, therefore, that the perception of the slightest variation in the rates of vibration can theoretically be perceived ; practically, differences of one sixty-fourth of a tone can be recognized by the trained ear ; in the higher registers, differences of half a vibration per second can be distinguished by skilled musicians.

Nothing has been said in the preceding pages about the influence exerted upon the transmission of fluid waves by the communication between the endolymphatic and perilymphatic channels and the intracranial lymph spaces. It is probable that, owing to the small calibre of the communicating canals, the friction of the fluid is so great that their presence is no protection against a sudden increase in tension of the labyrinthine fluid, sudden augmentation in pressure being compensated for by the elastic septum covering the round window. When, however, the increase in pressure within the labyrinth is very slow, such as would result from a chronic process within the middle ear with the production of new connective-tissue elements, crowding the stapes slowly into the oval window, it is probable that the equilibrium of the labyrinthine fluid would be preserved, in part at least, by its passage into the intracranial lymph spaces.

---

* Arch. für Ohrenheilk, vol. xxiv, p. 54.

The perception of musical notes by the agency of the cochlea has been considered first on account of its complexity; but it must be remembered that the maculæ of the saccule and utricle and the cristæ of the ampullæ also contain the terminal filaments of the eighth nerve. It is probable that noises and perhaps also certain musical sounds are perceived here. It would also seem that these structures are particularly designed for the reception of vibrations of great amplitude, which are interpreted as sound, but that complex sounds are not fully analyzed here, although certain variations in pitch are recognized. The otoliths are found here and prevent too extensive excursions of the ciliæ; their presence in these regions alone rather adds weight to the theory that this portion of the labyrinth is designed for the reception of vibrations of considerable amplitude, whether occurring as musical notes or following each other irregularly, giving the impression of a noise. It seems certain that the ultimate analysis of musical tones can only take place in the cochlea; and hence, from the anatomical structure of the parts, the musical notes whose perception would be first interfered with in any involvement of the labyrinth following a pathological process within the tympanum should be those perceived by the basilar membrane at the lowest part of the cochlea, or that portion close to the tympanum. Clinical experience supports this view, since in secondary labyrinthine affections we find that defective perception for the highest notes of the scale is an early symptom.

The Semicircular Canals.—From experiments upon animals and from clinical observations it is supposed that the semicircular canals are concerned in maintaining the equilibrium of the body, and in recognizing any departure from this condition. How much this function contributes to the ability to judge of the location from which a given sound comes can not be determined, but it is probable that the position which the head assumes, in order that the ear may receive the maximum impression of the sounding body, conveys to the perceptive centre, through the agency of the semicircular canals, a certain stimulus which enables the listener to locate the approximate position of the sounding body. Recently Ewald * has attributed to the semicircular canals the power of interpreting a sixth special sense, which he denominates as the muscular sense or muscle-tonus, holding that the perception and maintenance of stable equilibrium are regulated by the semicircular canals through this special sense. Such a claim is difficult to controvert. Any change in muscle-tonus must disturb the equilibrium of the body to a certain degree, and this in turn would depend for its appreciation upon the integrity of the semicircular canals. That these portions of the internal ear are the perceptive organs of the sixth special sense has not, I think, been conclusively proved.

The Effect of Changes within the Middle Ear upon the Labyrinth.—Since the labyrinthine fluid is separated from the tympanic cavity by an elastic membrane at the round window and at the oval window by a movable osseous septum, the foot-plate of the stapes, it follows that changes in the tension of the ossicular chain, due to relaxation or contraction of the elastic structures within the middle ear, must cause variations of pressure in the labyrinthine fluid. Shortening of the ossicular ligaments and of the tensor tympani muscle will effect this change; or the same result might be brought about by a rarefaction of the air within the tympanum, the tension then being increased by the atmospheric pressure without. Any force acting to displace the foot-plate of the stapes inward, causes a similar displacement of the labyrinthine fluid and an outward excursion of the membrane at the round window, the extent to which this membrane is moved outward depending upon its elasticity. Any sudden increase in pressure must be compensated for by a corresponding displacement of this elastic lamella, since the friction of the fluid against the walls of the narrow aqueductus vestibuli and aqueductus cochleæ would prevent an outward flow in this direction. If the pressure was maintained for a considerable time, a gradual outflow of fluid through these channels would undoubtedly take place, and the equilibrium would be restored.

---

* Physiolog. Untersuch. über der Endorg. des Nerv. Octavus. Wiesbaden, 1892.

Bezold * has shown that the excursions of the membrane of the round window are four times as extensive as those of the foot-plate of the stapes, in response to any given force displacing the latter inward. The area of the stapedial foot-plate is greater than that of the membrana tympani secondaria, and hence displacements of this latter structure must be correspondingly more extensive.

When we come to consider the effect of condensation and rarefaction of the air in the tympanic cavity upon the tension of the labyrinthine fluid, the mechanism of the malleo-incudal articulation must be borne in mind. The effect of increased aërial pressure within the tympanic cavity would naturally be to force the drum membrane outward. This outward movement would be participated in by the malleus, and through its articulation with the incus would be communicated to this ossicle, which in turn would cause an outward movement of the stapes, with a reduction of the pressure within the labyrinth. From the peculiar construction of the malleo-incudal joint, very extensive outward excursions of the manubrium cause a separation of the articular surfaces of the ossicle, and the stapes is displaced outward to a comparatively slight degree as compared with the excursion of the membrana tympani. The membrana tympani has but little elasticity, owing to the peculiar structure of the lamina propria, and after the maximum outward displacement has taken place it forms a rigid wall. Beyond this, any increased pressure within the tympanum, due to the introduction either of air or fluid, causes an augmentation of labyrinthine tension, the cavity being closed on all sides by rigid walls, with the exception of those portions of the inner walls occupied by the oval and round windows. This increased pressure acts upon both the foot-plate of the stapes and the membrana tympani secondaria, since they constitute the areas of least resistance, and their inward displacement is opposed only by the normal tension of the labyrinthine fluid, which is slightly less than that of the normal atmospheric pressure. When the pressure within the tympanum is increased by artificial means, or as the result of pathological processes, and the cavity has attained its great-

---

* Politzer, Lehrbuch der Ohrenheilk., Wien, 1893, p. 54.

est dimensions by the maximum displacement of the membrana tympani outward, the next result is a displacement of the membrana tympani secondaria and of the foot-plate of the stapes inward, increasing the tension of the perilymph. The movement of the stapes toward the vestibule is permitted by the separation of the articular surfaces of the malleus and incus. The changes in the endolymphatic pressure are the same as those in the perilymph. This explains the phenomenon observed frequently after over-inflation of the tympanum, functional examination indicating increased labyrinthine tension in spite of the fact that the membrana tympani has been restored to its normal position.

Politzer * has shown from experiments that aspiration of the tympanum—that is, artificially diminishing the aërial pressure within it—lowers the labyrinthine pressure instead of increasing it. We might suppose at first that this latter condition would result on account of the inward displacement of the ossicular chain from the pressure of the atmosphere. This diminution of labyrinthine tension following aspiration of the tympanum is caused by the reduction in pressure over both the oval and round windows, which more than compensates for the inward displacement of the stapes by the atmospheric pressure from without. In Politzer's experiments the pressure within the labyrinth was equal to the pressure of the atmosphere, while during life we know that it is slightly less than this, and in this condition a moderate reduction of tension in the intratympanic air would lower labyrinthine tension considerably. As soon as the pressure in the middle ear is greatly reduced, labyrinthine tension must increase from the extensive inward excursion of the stapes. The truth of these conclusions is demonstrated by the effect of aspiration and auto-inflation upon the perception of sounds of different pitch, as well as the influence which these procedures exert upon the conduction of sound through the solid media of the skull. It has been proved by Bezold and Siebenmann † that a sudden increase in labyrinthine pressure renders the perception of high notes more keen, and increases bone-conduction as a rule. The over-inflation of the tympanum has been found by the same investigators to effect similar changes. Aspiration of the middle ear, on the other hand, according to

---

* *Op. cit.*, p. 54.

† Arch. of Otol., vol. xxii, p. 1.

Siebenmann,* usually diminishes bone-conduction—a result which we should expect from the reduction of labyrinthine pressure. The power of hearing high notes is not particularly affected by this procedure, on account of the short wave-lengths of such sounds and the proximity of the area to the middle ear of the cochlea specialized for their reception. If the perception of high notes is at all affected, it is rendered less keen.

Increased tension within the labyrinth from displacements of the ossicular chain inward—a condition which may be brought about from a shortening of the muscular or ligamentous structures attached—is corrected, up to a certain point, by a displacement of the membrana tympani secondaria in the opposite direction. When the limit of its elasticity is reached, the perilymph can no longer vibrate. Up to this point, however, the entrance of sound waves into the labyrinth is not prevented. Under certain pathological conditions the membrane of the round window becomes thickened and loses its elasticity. When this occurs even a moderate displacement of the stapes inward may be sufficient to render vibration of the labyrinthine fluid impossible. This rigidity at the round window exerts a greater influence when sudden changes in labyrinthine tension occur from extensive and sudden displacement of the membrana tympani and ossicular chain inward, than where these changes come on gradually. When the pressure is slowly increased, a compensatory outflow of the labyrinthine fluid through the channels of communication with the intracranial lymph spaces is possible; but sudden augmentation of tension can not be relieved in this way, on account of the friction of the column of fluid against the walls of the capillary passages through which it is forced. This explains why we find so great a reduction of the upper tone-limit in sudden closure of the Eustachian tube, while proliferative changes within the middle ear cause secondary labyrinthine involvement only after a long period—in the one case, pressure being increased suddenly, in the other case, gradually.

The individual parts of the auditory tract having been considered, a few words may not be out of place in reviewing its action as a whole.

---

* *Loc. cit.*

Under ordinary conditions, sonorous impulses, projected through the air, reach the end-organ of the nerve specialized for sound perception by the transmutation of aërial waves of condensation and rarefaction, through the agency of the tympanic structures, into waves of similar character in the labyrinthine fluid. These waves in turn impress the terminal filaments of the auditory nerve in a specific manner. Normally, then, sounds are best heard through the air; it is possible, however, for the fluid within the labyrinth to be set in vibration through the medium of the cranial bones, resulting in the phenomenon of sound perception. When the labyrinth is intact, musical notes are interpreted with a fair degree of accuracy when they reach the labyrinth by bone-conduction—that is, when the vibrating body is brought in contact with the bones of the head. There are reasons for believing that even when the labyrinth is seriously affected the auditory nerve itself may react to vibrations which are conveyed to it through the bones of the skull. An explanation of this fact is offered by Gad,* who advances the hypothesis that under normal conditions the auditory nerve-trunk not only transmits stimuli resulting from the analysis of complex sounds by the labyrinth, but is also excited by the impulses of the vibrating body acting as a mechanical stimulus. This last effect will not be prevented by the destruction of the portion of the nerve designed for the analysis of sound, the impression received affecting the sensorium as a whole rather than as distinct individual notes. The increased electric irritability of the nerve, so often found where the labyrinth has been destroyed in the course of physiological experiments, rather adds weight to this view. Even where the labyrinth is entirely separated from the auditory nerve-trunk, the excitation of the nerve by sounding bodies of different pitch would probably produce different effects upon the perceptive centres, although the exact differences could not be defined by the subject. In this hypothesis the auditory nerve follows the laws which govern the reaction of all sensory and motor nerves to stimuli of various kinds, whether they be thermal, mechanical, or electrical. The weak point of this theory lies in the fact that in physiological experiments one can never be certain that the cochlea has been entirely destroyed, while in cases of exfoliation of the cochlea in man, as the result of disease, the process has usually been unilateral, and the part played by the unaffected ear can not be excluded with certainty. Corradi* has demonstrated by experiment, that in the porpoise destruction of both cochleæ causes complete deafness; but it is not safe to say that the same result will follow in the human species. It is enough for practical purposes to remember that the exact interpretation of sound is only possible when the cochlea is intact; while it is probable that the stimulation of the nerve-trunk itself may be effected by a sounding body or other stimulus, even if the end-organ has been destroyed.

---

* Schwartze, Handb. der Ohren., 1892, vol. i, p. 348.

The Concerted Action of the Auditory Apparatus.—It is still a question of dispute as to the exact influence exerted by the auditory organ of one side upon that of the opposite side of the body. Unquestionably the hearing is most delicate when both organs are in perfect condition. If one ear is occluded by the finger or obstructed from any pathological process, sound perception becomes less acute, and the power to distinguish the location of a sounding body is correspondingly interfered with. No doubt the correlation of the organs of the opposite sides depends largely upon the decussation of the fibres of the cochlear nerve in the brain, as described in the pages devoted to anatomy of the auditory nerve. It must be remembered, however, that if perfect audition presupposes the anatomical perfection of both organs, a condition might exist in which the transmission of sonorous waves by the apparatus of one side would be so incorrect as to interfere with the perception of those conveyed through the auditory organ of the opposite side. Cases are met with in which the hearing can be improved by completely occluding one ear artificially, thus excluding the sound waves from it. That in the normal subject binaural audition is better than monaural is explained, according to Urbantschitsch,† by the fact that the stimulation of the peripheral organ of the auditory nerve on one side, renders the perceptive centre on the corresponding side, and which receives fibres from the opposite ear, more susceptible to the action of the sound waves. This excitation of the receptive centre renders it responsive to slight stimuli reaching it through the opposite ear. In support of this argument, we recall the fact that the acuteness of audition upon one side for any given sound will be increased if the organ of the opposite side is at the same time brought under the influence of sound waves of a different character; thus, for instance, a watch may be more clearly perceived in the right ear if a vibrating tuning fork is held close to the meatus of the left. In this way Urbantschitsch explains the phenomenon of paracousis Willisii, the action of loud sounds serving to stimulate the receptive centres, after which relatively feeble stimuli, as vibrations of small amplitude, may be perceived. Binaural audition, then, would owe its acuteness to the exciting action of one auditory centre upon the other. Politzer,* on the other hand, believes that the greater acuteness of binaural audition depends upon the fact that it represents the effect of an impulse acting upon a greater area, and hence producing a more marked impression, upon purely mechanical principles. This latter suggestion seems the more simple, and yet a close observation of the phenomena produced by various pathological processes reveals the existence of such an intimate interdependence between the organs of the opposite sides, that it is hard to believe that this association does not play an important part under normal as well as under pathological conditions.

---

* Archiv für Ohrenheilk, vol. xxxii, p. 1.

† Lehrb. der Ohren., Wien, 1890, p. 416. Arch. für Ohrenheilk., vol. xxxv, p. 1.

Reflex Phenomena.—We have spoken at length of the action of one auditory organ upon the other, but it must not be forgotten that the nucleus of the eighth nerve of either side communicates not only with its fellow, but is intimately associated with the central nuclei of the other cranial nerves, as well as with various spinal centres. The function of the ear is affected not only by the action of sonorous waves, but also reflexly by the action of various stimuli upon other centres with which the auditory is in intimate relation. Conversely, any excitation of the sound-perceiving apparatus may effect psychical, sensory, or motor changes in remote regions of the body. The phenomenon, often observed, of starting at any sudden sound undoubtedly depends upon reflex action; the association between particular sounds various colors and is an example of the curious effect produced on account of the communicating fibres between the acoustic and visual centres. On the other hand, the power of audition may be perverted or annulled reflexly, by a pathological condition affecting fibres of a nerve trunk, the centres of which are intimately associated with the auditory nerve nuclei.

---

* *Op. cit.*, p. 516.

Phenomena dependent upon Circulatory Changes.—Through the intimate relation which exists between the blood-vessels of the labyrinth, the tympanum, the higher nerve centres presiding over audition and the cervical sympathetic, it is plain that circulatory changes must exert an important influence upon the function of audition, perverting or impairing it, either indirectly by inducing vascular changes within the tympanum or directly by causing circulatory changes in the end organ or ganglia of the eighth nerve. This fact is to be particularly remembered in considering certain subjective symptoms frequently complained of, experience showing that correction of vaso-motor tone often relieves the manifestations. On the other hand, disturbances in the blood supply may depend upon actual organic changes in the vessels or in the blood itself. It is evident, especially in the consideration of subjective phenomena, that there exists a broad field for speculation, not only in diagnosis, but also in the selection of appropriate therapeutic measures.

Secondary Phenomena.—In this same line lie those disturbances, both objective and subjective, which depend upon a morbid process in some other organ of the body. Here we may mention the symptoms met with in connection with congestive derangements of the larger viscera, and relieved only by remedies appropriate for the correction of the exciting cause. Disturbance of the auditory centres in the female is not uncommon in uterine and ovarian disorders.

The relation between ocular and aural derangements has lately been emphasized by Oliver and Cleveland; * many of these must be reflex in character. The reflex disturbances of the most importance are those occurring in the domain of the trigeminal nerve. This nerve supplies many filaments to the external and middle ear, and in the latter location, it will be remembered, a close association exists between the cranial and sympathetic nerves. As a result, any morbid condition which involves parts supplied by the trigeminus may, by involvement of the nerve elements which they contain, so interfere with the trophic supply of some portion of the ear as to cause not only functional disturbances but even organic changes in the tissues.

---

* Burnett's System of Diseases of the Ear, Nose, and Throat. Philadelphia, 1893, vol. i, p. 516.

In this connection the influence of dental caries is the most familiar instance, it having been proved that decayed teeth may produce not only a functional disturbance of the organ of hearing, but also an acute inflammation of the tympanum. Most interesting, also, is the close relation between corresponding parts of the auditory apparatus of the opposite sides of the body. Here, no doubt, the phenomena observed depend upon reflex action through the sympathetic and cranial nerves and, in many cases, upon the decussation of the auditory fibres within the brain. The effect is at first reflex in character, but later the result of degeneration or atrophy. The so-called "sympathy" between the ear of one side with that of its fellow was recognized by Kramer,[*] Wharton Jones,[†] and many other early writers. Recently Urbantschitsch [‡] has written extensively upon the subject.

The effect of increased labyrinthine tension from rigidity and displacement inward of the ossicular chain upon the function of the opposite ear is made prominent by Weber-Liel [#] and by Cholewa.[‖] The writer [△] has also called attention to the fact, especially in cases operated upon for chronic inflammatory conditions of the tympanum, that the function of the opposite ear has been improved after operation. Gellé [◊] is inclined to look upon the temporary impairment of function observed when the meatus is closed with the finger, while at the same time a vibrating body is held close to the unobstructed meatus, as due to a reflex contraction of the tensor tympani muscle upon the non-occluded side, and makes use of the experiment to prove the integrity of the upper cervical nerves, these being comprised in the reflex chain. It seems to me that the manifestation can be better accounted for by the direct effect of the pressure upon the end organ of the acoustic nerve, and the transmission of the stimulus to the perceptive centres of both sides.

---

[*] Ohrenheilk., 1836, p. 145.

[†] Frank's Ohrenheilk., 1845, p. 133.

[‡] Arch. für Ohrenheilk, 1893, vol. xxxv, p. 1.

[#] Monatsschr. für Ohrenheilk, 1874, No. 6.

[‖] Arch. of Otol., vol. xix, p. 151.

[△] N. Y. Eye and Ear Infirmary Reports, vol. i, p. 50, vol. ii, p, 62. Wood's Reference Handbook of the Medical Sciences. New York, 1893. (Supplement.) Art. "Middle Ear Operations,"

[◊] Arch. für Ohrenheilk, vol. xxviii, p. 58.

Like other nerves, the auditory trunk may be rendered less capable of transmitting impulses either by overuse or disuse, and for the same reasons the higher receptive centres may cease to functionate properly. Thus, if the ear is subjected for a long time to the action of a single sound, this particular note will, after a time, cease to be perceived as readily as at the beginning of the experiment, although perception for other notes of the scale will be unaffected. If, on the other hand, the nerve is allowed to remain inactive for a long period, as where serious obstruction to sound conduction has rendered the ear of little practical use, it is found that even after the removal of the obstruction and the restoration of the conducting mechanism to a normal condition, the function of the ear is imperfect from the fact that the nerve has been so long at rest that it is not able to subserve the purpose for which it was designed. On the other hand, after the nerve trunk and receptive centres have been once excited, they react more readily to stimuli and require less energy to maintain them in a condition of irritability than would be required to arouse them from a state of repose. It is frequently found, in testing the hearing with a watch or other similar instrument, that the hearing distance will be greater if the sounding body is first held close to the ear and then gradually withdrawn until it is no longer heard, than if the experiment is reversed: the sounding body being gradually carried toward the ear from a point at which it is not perceived until a position is reached where it is distinctly audible. This means simply that the auditory nerve having once been excited, reacts to a stimulus of less intensity than that required for its initial excitation. On account of the decussation of the auditory fibres in the medulla, it is also true that the functional activity of the ear on one side may be increased by stimuli directed to the opposite ear.

Urbantschitsch * explains this upon the hypothesis that the excitation of the cortical centre of one side by means of sonorous vibrations acting upon the opposite ear renders sound per-

---

* Lehrb. der Ohren., 1890, p. 416.

ception more acute in the other ear on account of the decussation of the auditory fibres, through which the cortical centre receives fibres from the labyrinth of the corresponding and opposite sides. Stimulation of the opposite labyrinth increases the irritability of the centre and causes it to respond to a slighter stimulus, whether this is received through the corresponding or opposite end organ. I have already suggested such an influence in explaining the improvement observed in the organ not operated upon in cases subjected to operative procedures. Urbantschitsch * has so extended the field of possible utility in this direction that it is of the utmost importance to bear the relation in mind on account of its therapeutic usefulness. This writer urges that this stimulation of the perceptive centres may follow the action of sonorous vibrations, even if the ear acted upon is so defective as to be incapable of transmitting impulses to the degree necessary for actual sound perception on the part of the patient. In other words, when the organ of one side has been rendered entirely useless by sclerotic changes in the conducting mechanism, he deems it warrantable to relieve this physical abnormality before the influence which it may exert upon the opposite side can be decided.

We have discussed the effect upon the receptive centres of overstimulation by sonorous waves, and also the result following a long period of inactivity. It must be remembered that, like other nerve centres, the auditory nuclei and fibres react to other stimuli than those for which they were especially designed. Pressure upon the terminal filaments, trunk, or centre of the eighth nerve excites, perverts, or destroys its function. Slightly increased pressure upon the terminal filaments, from congestion of the labyrinth, may render the nerve exceedingly sensitive, and may give rise to subjective noises (paræsthesiæ). One of the most curious effects observed from this increased activity is the persistence of auditory impressions; for example, when a certain piece of music is played upon the piano, the hyperæsthetic centre may retain a mental picture of this for a long period, and the individual be annoyed for hours afterward by the subjective impression of hearing the selection continually, exactly as it has been played originally. In the same manner it is not an uncom-

---

* Arch. für Ohrenheilk., vol. xxxv, p. 1.

mon experience for patients to aver that they hear the tick of a watch even after the sound has ceased, the impression once received being maintained for a long interval. It is of great importance to bear this in mind in testing the hearing with any instrument, such as the watch or acoumeter, where the same sound is repeated, as otherwise erroneous conclusions will be reached.

Too great stimulation, either on account of the sudden condensation of air in the auditory canal, as when a loud explosion takes place close to the ear, or by loud sounds continued for a considerable period, may cause great impairment of hearing for varying intervals of time, the sudden increase in pressure, on the one hand, or the prolonged and intense excitation on the other, completely destroying either transiently or permanently the function of the delicate perceptive portions of the auditory system. Familiar examples of these effects are observed among artillerymen, in whom a temporary impairment of hearing is not uncommon, after exercise with the great guns of the battery. Among soldiers who have been under heavy fire for many days, the prolonged and excessive excitation of the receptive centre or of the terminal filaments of the nerve has been known to produce permanent results, although usually the impairment has been but temporary.

CHAPTER III.

PHYSICAL EXAMINATION.

Preliminary Observations.—Before describing in detail the instruments needed for the proper examination of the ear, let us recall briefly the topography of the region.

The external meatus is made up of two tubes, joined at an angle in both the vertical and horizontal planes, re-entrant downward and forward. The fundus of this canal constitutes the drum membrane, and is continuous with its cutaneous lining. The length of the entire passage, measured from its outermost point—that is, from the tragus to the drum membrane—is thirty-six millimetres, or about one inch and a half. This should be remembered as determining the proper length of instruments to be manipulated in the meatus. It should also be borne in mind that of this inch and a half, a little less than one inch of the tube is cartilaginous and a little over half an inch osseous. The general direction of the cartilaginous tube is upward, backward, and inward, while that of the bony conduit is downward, forward, and inward. For the satisfactory inspection of the deeper parts, it is evident that the axes of these canals must be made as nearly as possible coincident; as the outer portion is movable, traction upon the auricle upward and backward tends to bring the axes into the same straight line.

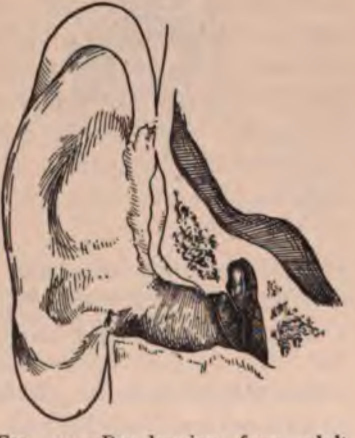


FIG. 25.—Pen-drawing from adult specimen, showing the result of drawing the auricle upward and backward. The axes of the bony and cartilaginous meatus are made coincident, permitttng an inspection of the drum membrane (actual size).

Fig. 25 illustrates the position assumed by the parts in the adult when the auricle is drawn upward, backward, and outward. It will be seen that the cartilaginous and bony meatus form practically a straight canal, the angle marking their junction having been obliterated by traction in the directions named.

In infants the superior and inferior walls of the meatus are in contact and must be separated before the membrana tympani can be seen. This is due to the absence of the bony meatus at birth. As the superior wall of the fibro-cartilaginous tube is attached to the squama, the separation of the walls can be effected only by traction downward and backward, the inferior wall being pulled away, so to speak, from the superior wall. Fig. 26 clearly demonstrates this fact, and it should be remembered that in young children the auricle should be drawn outward, backward, and downward in making a speculum examination.

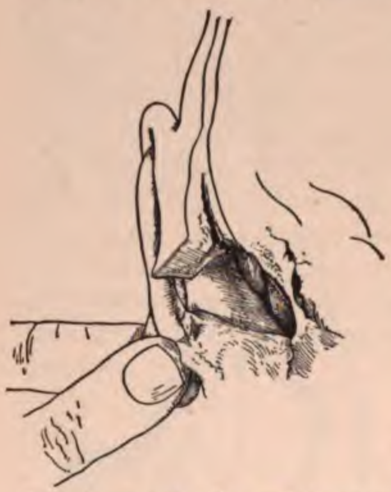


FIG. 26.—Drawing from specimen at birth. Traction must be made downward and backward to expose the membrana tympani (actual size).

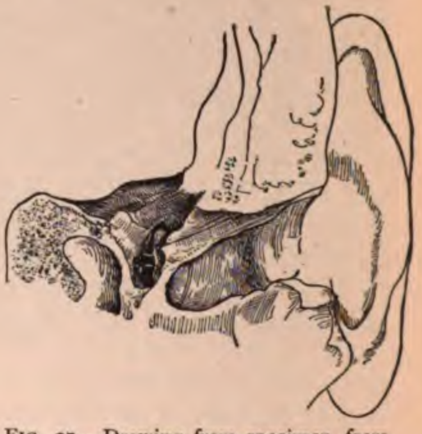


FIG. 27.—Drawing from specimen from child, aged five years. The development of the bony meatus has separated the superior and inferior walls, but traction downward will still expose the membrana tympani most completely (actual size).

In children several years old the development of the bony canal has effected this separation of the walls of the deep meatus, but even in these cases the membrana tympani is more clearly seen if the auricle is drawn slightly downward rather than upward. Fig. 27, drawn from a specimen taken from a child of five, makes this clear.

Since the cartilaginous meatus alone is dilatable, the field of inspection can not be increased in size by crowding a dilating instrument beyond the osseo-cartilaginous junction. On the other hand, since such a procedure fixes the two portions immovably at their angle of union, the field of inspection must be considerably narrowed. Moreover, an instrument of greater external dimensions than the calibre of the fibro-cartilaginous tube will crowd the soft parts inward toward the fibro-osseous junction, and this mass will obstruct the view of the deeper parts.

The fundus of the canal is formed by the drum membrane. This is obliquely placed both in the horizontal and vertical planes of the long axis of the meatus. The inferior margin of the membrane forms an angle with the horizontal plane of from thirty to forty degrees, while the anterior margin makes an angle of about one hundred degrees with the vertical median antero-posterior plane of the body. From the conformation of the meatus at its inner extremity, the angles which the membrana tympani makes with the posterior and superior walls are somewhat greater than those made with the vertical and horizontal planes. In other words, the drum membrane is really a continuation of the superior wall of the meatus, and, to a less extent, of the posterior. From this it follows that the superior and posterior margins of the membrane are nearer the orifice of the meatus than the inferior and anterior. In the young infant the membrana tympani lies in the plane of the surface of the squama. To be brought into view the operator must direct his glance upward toward the superior wall of the canal.

In investigating diseases of the ear it has been the custom to lay special emphasis upon the appearance of the drum membrane as observed upon ocular inspection, and to form opinions as to the prognosis of any malady largely from the information thus obtained. It should be remembered that in most cases we are consulted for an impairment or perversion of the function of the organ, and hence, while inspection of the visible parts is very important and should be made with all the skill attainable, it is also equally important to conduct a systematic functional examination, for the discovery of the location, extent, and nature of the pathological condition responsible for the symptoms complained of by the patient, and to determine as well to what extent the power of sound perception is interfered with, the normal ear being taken as the standard in conducting such tests. In this manner we can more intelligibly estimate the amount of damage done, and, combining the information obtained both from functional and physical examination, we arrive at an opinion of greater value than that obtained by ocular inspection merely.

To properly examine the parts so situated as to be open to ocular inspection it is necessary to secure a proper illumination of the region. From the depth and sinuous course of the auditory meatus, examination by direct illumination has never been as successful as when the light has been reflected upon the parts by means of a mirror.

The Source of Light.—We have to consider, in the first place, the source of light. If sunlight could always be depended upon it would, no doubt, be the best source of illumination for an otoscopic examination. The direct rays of the sun, when reflected into the ear, produce such a brilliant illumination of the parts that detail is obscured. Diffuse daylight or light from a white cloud forms a very perfect source of illumination, but naturally can not always be obtained. I am in the habit, therefore, of advising students to accustom themselves to the various appearances as seen by artificial light. An ordinary oil lamp, if fitted with a duplex or other powerful burner, is an excellent source of illumination. The same can be said of an Argand gas-burner; even a common candle emits sufficient light to enable the surgeon to make a perfect examination, and to perform any operation within the canal which an emergency might demand. At least one of these means of artificial illumination can be found in any house, and familiarity with normal and pathological appearances when viewed by such light can not fail to be of great service to the otologist, who is often obliged to make an examination at the bedside. For convenience in making an examination at the bedside, as an adequate source of illumination may not always be obtainable without delay, or may demand the aid of an assistant to permit of a proper examination without moving the patient, it is well for the examiner to be provided for such an emergency. For this purpose use may be made of the device shown in Fig. 28, which consists of a clamp which may be fastened to a table, chair, the frame of the bedstead, or any other firm object in the room, as may be convenient. This clamp carries a jointed rod, which supports a short arm for holding an ordinary candle. For city practice the ordinary fish-tail gas-burner may be substituted in place of the candle, the burner being attached to a small metal band which fits into the candle-holder. This burner is connected with a gas fixture in the room by means of a flexi-

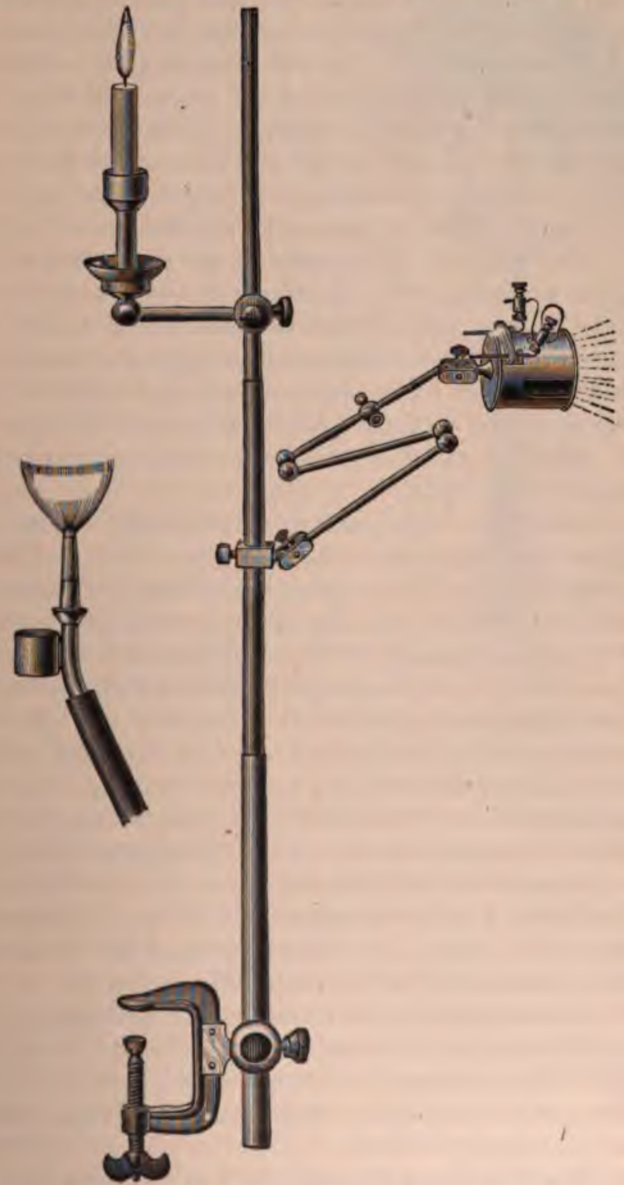


FIG. 28.—Author's portable illuminating apparatus. In the figure the candle and electric lamp are in position; the gas-burner is shown in the detached drawing on the left.

ble pipe attached to it. This apparatus enables one to secure a fairly efficient source of illumination and to place the light in exactly the position from which he may make the examination with greatest comfort to the patient and to himself, and renders the entire procedure less laborious and correspondingly more exact. The entire apparatus occupies but little space in the instrument bag, and greatly facilitates bedside examination. A small electric lamp suitable for operative work can also be attached to the vertical rod, while a light shelf for supporting an oil lamp can be fitted upon the arm carrying the candle, if the examiner prefers this source of illumination.

The different appearance of the parts viewed by artificial light as compared with the picture seen when diffuse daylight is employed, depends upon the fact that all artificial sources of illumination contain a preponderance of yellow rays, and hence the reds and yellows are slightly exaggerated in the otoscopic picture. No mistake need be made if this fact is borne in mind, even by an observer accustomed to the use of white light.

Since the introduction of electricity as an illuminating agent its employment in otological work has become quite common. The rays which the incandescent lamp yields are almost colorless, and any desired intensity can be obtained. The reflected image of the luminous carbon band sometimes gives rise to annoyance—a difficulty which can be obviated by the employment of a system of mirrors, the effect of which is to obliterate the image entirely and yield only a diffuse white light, which the surgeon can then reflect into the ear by means of the mirror. A manifest objection to the electric light lies in the fact that it is not always obtainable, although this is in a measure overcome by the introduction of portable storage batteries. Its greatest advantage is that when ether anæsthesia is required, there is no danger of ignition of the vapor, since the luminous carbon is completely inclosed.

As electricity, even when carefully handled, is a somewhat capricious agent, it is well for the operator to be supplied with an additional source of illumination in every case, so that in the event of the electric apparatus failing, some other efficient means may be at hand.

The Reflecting Mirror.—It was formerly the practice in examining the ear by means of reflected light, to direct the rays into the canal by a plane or concave mirror fixed upon a short handle (Fig. 29), and held in one hand, while the other hand grasped the auricle and supported the speculum in the proper position. Obviously the most correct information is obtainable by the simultaneous inspection and manipulation of the parts; it is necessary, therefore, that the surgeon have one hand free for the use of a delicate probe. At the present day the reflecting mirror is usually worn upon the forehead, and the polished surface is concave, thus bringing the luminous rays to a focus in front of the mirror. The light will be most intense at the principal focus of the instrument, and the best definition will be obtained at a point just within this; hence the focal distance of the mirror should be such that when the parts are perfectly illuminated, the eye may be as near as possible to the region to be examined, while at the same time sufficient space intervenes between the ear of the patient and the surface of the mirror for the manipulation of such instruments as it may be necessary to use. It is seldom practicable for the eye of the observer to be less than eight or ten inches from the deepest part of the region under inspection. In selecting a mirror, therefore, the focal distance should not be less than seven inches, nor more than eleven inches. This fact should be borne in mind in choosing the instrument, and can be most easily ascertained by noting the distance between the mirror and the hand when the rays of light are brought to a focus upon the palm. Where artificial light is used, the rays are divergent, and hence the conjugate focus for such rays will be more remote than the principal focus, which is the point to which the parallel rays are converged. It is also advisable to be provided with a mirror which will serve for an examination of the ear, and of the nose and naso-pharynx as well. For the inspection of the regions last named the focal length of the mirror should be slightly greater than of one which is suitable for otological work alone. A mirror of

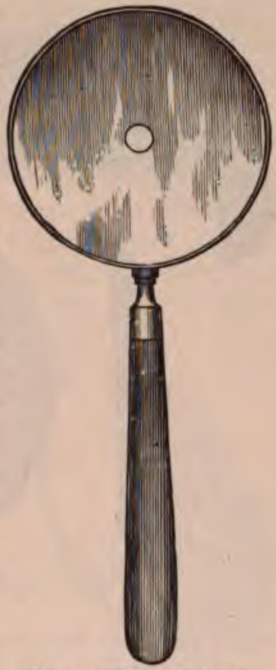


FIG. 29.—Hand mirror.

from eight to ten inches focal length for divergent rays is well adapted to general use, it being only necessary to move the source of light a little nearer the mirror when the throat or nose is to be examined.

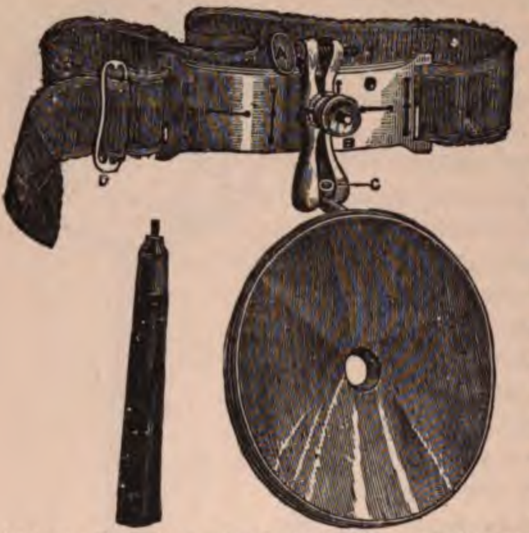


FIG. 30.—Reflecting mirror, adapted for use both as a head or hand mirror.

If the illuminating apparatus is provided with a condensing lens which renders the rays parallel, the focal distance as determined by sunlight will be correct; otherwise a mirror of shorter focal length for parallel rays than that given above should be selected. It is easy to determine whether the mirror is perfectly ground by observing the image of the gas flame or candle at the focal point of the mirror; if the rays are thrown upon the hand or upon a sheet of white paper, we should secure a sharply defined image of the particular flame with which we are experimenting; if the edges of the image are blurred, the mirror is practically useless for delicate work. The size of the mirror is also important; those sold in the shops are usually perforated in the centre, the mirror being worn in such manner that the perforation will lie over one or the other eye, thus bringing the visual ray of the examiner through the centre of the cone of reflected light. When the mirror is worn in this way its diameter should not be greater than three and a half inches; a diameter of two and a half inches is fully sufficient.

Certain observers prefer to wear the mirror upon the forehead, in which case the eye of the examiner does not look directly through the cone of light, the rays illuminating the parts to be inspected being reflected from them at an acute angle to the eye of the observer. When this method of examination is employed the diameter of the mirror is immaterial, but nothing is gained by increasing the area of the reflecting surface. Still other observers wear the mirror in such way that its superior border is below the orbits, the mirror lying directly over the nose, and the examiner looks over the top of the glass rather than through its centre. It certainly seems more simple to perfectly illuminate the parts by the first method of examination, since the position which permits of the most perfect inspection gives at the same time the most perfect illumination. This, however, is a matter of practice, and after becoming accustomed to one method of examination it is unnecessary to change, equally good work being possible by all methods. It should be emphasized, however, that the beginner will do well to employ one method constantly, and not attempt to become expert at several.

Sometimes the source of light is an incandescent lamp worn upon the head of the examiner, the instrument being provided with lenses which focus the rays upon the parts to be inspected; such a light is worn either upon the forehead (Fig. 33) or lower down upon the bridge of the nose. Considerable practice is necessary in order to become expert in the use of such a device for purposes of examination, even after one is familiar with the use of the head mirror.

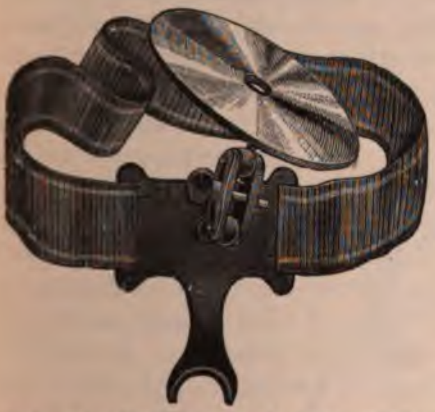


FIG. 31.—Head mirror, with nasal support.

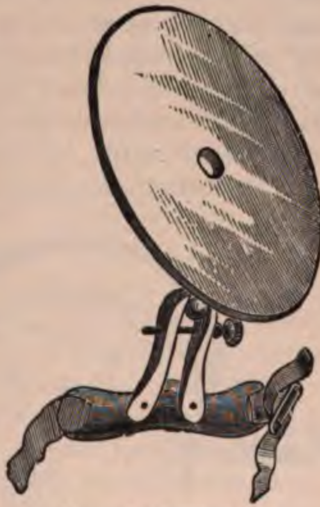


FIG. 32.—Head mirror.

The objection to a mirror of large diameter lies in the fact that when the central perforation is used, the border of the mirror lying close to the uncovered eye interferes with the perfect relaxation of the organ. This constitutes a source of eye strain, and after the instrument has been worn for several hours considerable discomfort is occasioned.

Regarding binocular inspection of the parts, it is manifestly impossible to view so small an object as the membrana tympani, with both eyes through a narrow canal, since the length of the canal and the small diameter of the entrance of the meatus would render it necessary to have the examiner so far away from the object to be examined, that the exact structure could be seen no longer. The eye not in use should be completely relaxed, and the beginner should under no circumstances close it, as the muscular exertion which this entails becomes a source of great discomfort after a comparatively short time. When the examiner is accustomed to make use of the central perforation in the mirror, and desires to use an incandescent light, this may be arranged upon a standard as shown in Fig. 28, the rays from the lamp being reflected into the canal in the same manner as when any other source of illumination is employed. The focal length of the condensing lens under such circumstances is a matter of great importance; its focal distance should be such that the rays are rendered parallel or slightly divergent when they strike the mirror. If convergent rays fall upon the reflecting surface, the result will be that the light will be brought to a focus at a point within the true focal distance of the mirror, beyond which point they will again diverge, and the illumination of the parts will be imperfect unless the head is brought so close to the ear as to render instrumentation within the canal impossible. Some prefer to wear the incandescent light upon the forehead (Fig. 33), dispensing with

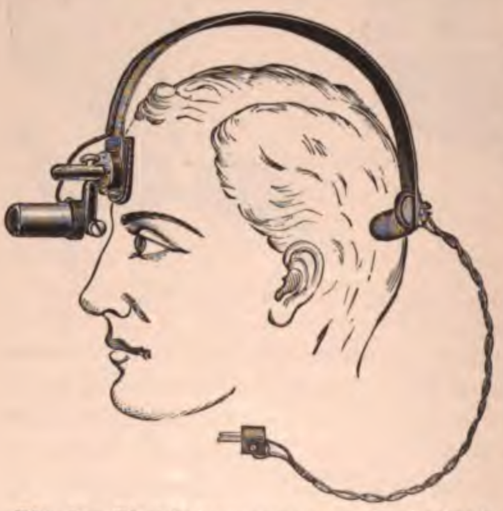


FIG. 33.—Electric lamp worn upon the forehead.

the head mirror entirely, the rays being brought to a focus upon the deeper parts within the canal by means of a series of lenses of proper curvature. Those accustomed to the use of the head mirror upon the forehead will find no difficulty in this method of examination. Where one habitually uses the central perforation in the mirror, the instrument being worn over one eye, considerable practice is necessary to become expert in using the incandescent light directly. This is, in a measure, overcome by making use of a device consisting of a head mirror, to the periphery of which a small incandescent light is attached; a metallic reflector and shade surround the lamp and direct the luminous rays upon the surface of the mirror, after which they are thrown into the canal in the same manner as when a stationary lamp is used. I repeat here, that all electric apparatus is apt to be capricious, and that it is well in operating outside of a hospital, where all appliances can be obtained at a few moments' notice, to be provided with another source of light in case of accident to the incandescent lamp. For my own use, the portable standard shown in Fig. 28 is so arranged as to support both the incandescent lamp and an ordinary gas-burner, the latter being connected with any convenient gas fixture in the room, and care being taken to have it in perfect working order before any operation is begun. The knowledge that an accident to the battery or lamp will not prove a source of annoyance is a great mental satisfaction to the operator.

Aural Specula.—In order to inspect the deeper parts of the meatus, the membrana tympani, and the tympanic cavity, it is necessary to separate the walls of the cartilaginous canal, and to overcome the irregularities, at the same time changing the axis of this tube to correspond with that of the osseous meatus. This latter object is attained by traction upon the auricle in a direction upward, backward, and outward, while the walls of the canal are at the same time separated and maintained in a position by the aural speculum. These instruments may be made of hard rubber, metal, or even of stiff paper, and vary in shape. Individual choice plays a prominent part in the selection of the particular form of instrument to be employed, but certain rules, applicable to all instruments of this character, must be borne in mind. The material of which the speculum is made must be as thin as possible, in order to secure the maximum field of inspection;

many of the instruments sold are so thick and heavy that, although the outside diameter is comparatively large, the calibre is very small, and when the meatus is narrow an instrument that can be introduced with comfort to the patient yields but a small area for inspection. Care should be taken that the end of the instrument inserted into the meatus has a perfectly smooth margin, as any irregularity of outline is sure to cause discomfort to the patient, and in children, to begin with an unfortunate accident of this kind may render an examination almost impossible. The length of the speculum is also a matter to demand attention. It is essential that the instrument shall project no farther beyond the entrance of the meatus than is necessary to permit of its being firmly held, since the difficulty of examination becomes greater when the observer is obliged to direct the light through a long, narrow passage to illuminate a small area at its extremity, and at the same time recognize minute variations in the condition of the parts. Under the most favorable circumstances the meatus itself presents obstacles which render an exact interpretation of the conditions observed very difficult, and to increase the length of the passage is to add greatly to these. The speculum should be just long enough to allow the surgeon to hold it firmly when in position and no longer. It is also important that the portion of the tube introduced into the canal should taper slightly, since the deeper parts are less distensible than those more superficially placed, and if the speculum fills the canal completely it can not be tilted in different directions, so as to bring the various portions of the fundus into view. The exact shape is unimportant; some examiners prefer an instrument the orifice of which is circular in outline, while others advise that it be oval, corresponding in form to the lumen of the canal as seen in cross section. The instrument

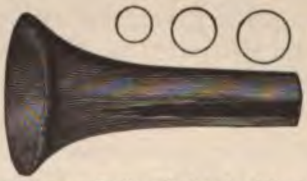


FIG. 34.—Politzer's hard rubber aural speculum.

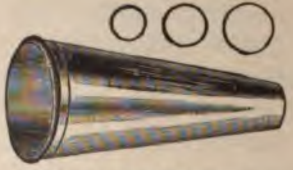


FIG. 35.—Wilde's aural speculum.

bearing the name of Wilde is conical, and the orifice circular, while in Gruber's speculum the tube is oval on cross section, and instead of being conical is somewhat funnel-shaped. This last feature is observed in the instruments of Troeltsch, Boucheron, Toynbee, Politzer, and others. Many prefer a single instrument which can be adjusted to the lumen of any canal by means of a set screw, the device resembling in construction the bivalve speculum of the rhinologist. In some instances it is advantageous to have one wall of the tube cut away for a certain distance in order that the meatus may be inspected after the instrument has been inserted. This end is best accomplished by employing a wire speculum, the walls of the meatus being separated by the elasticity of the material of which it is constructed. In an emergency a very serviceable speculum can be made with a piece of stiff note paper, twisted into the form of an elongated cone, the free edges of the paper being secured by a pin, a stitch, or by mucilage. This cone is then cut off at such a distance from the apex as will allow it to be easily inserted into the meatus, while in the other direction it is so cut as to reduce it to a proper length. Such an improvised instrument answers perfectly well not only for diagnosis, but also for operative purposes. In fact, I frequently use them in preference to metal specula, even when the latter are at hand. Their chief advantage is their cleanliness, the same cone never being used a second time.

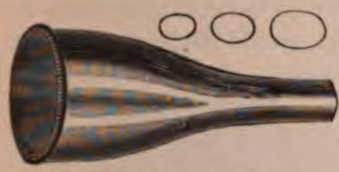


FIG. 36.—Gruber's aural speculum.

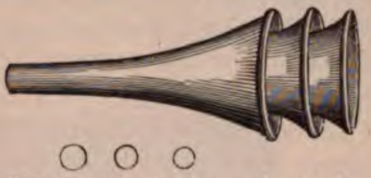


FIG. 37.—Toynbee's aural specula. (The instruments are too long, and the cut is introduced to show this.)

Whatever form of speculum may be chosen, attention to the above points will result in the selection of a serviceable instrument. Exact shape is immaterial, as constant use will soon enable the surgeon to become expert with any one of the various varieties. One possible advantage possessed by the funnel-shaped instruments, in which the outer opening is very wide, is that the examiner can more easily direct the light into the speculum than when the smaller instrument of Wilde is used. Whether the interior of the instrument is polished or blackened also depends upon individual preference. The contrast of the black background may be an advantage, but a certain amount of brilliancy of illumination is sacrificed.

It is necessary to be provided with specula of various sizes, and at least three are necessary to meet the differences in diameter of the orifice of the meatus, while five or six sizes are still more advantageous. The proper diameter, according to Richards,[*] of the smaller end of each speculum in a set of five of the Wilde pattern is given below, and will be found valuable: 7 mm., 6 mm., 4·66 mm., 4 mm., 3·5 mm.

Being provided with a satisfactory source of light, a proper head mirror, and a suitable speculum, the next step will be the technique of the examination.

The Technique of Examination (Fig. 38).—The patient and examiner may both be seated, a position which I decidedly prefer, or both may stand, or the patient may sit while the physician remains standing. The patient is best seated in a high-backed chair, in an attitude which can be maintained for some time without discomfort, the head resting against the back of the chair, the affected ear being turned toward the examiner. The surgeon, either sitting or standing, should occupy a position to the right of the patient rather than directly facing the affected side. Sitting or standing, this latter position must be an awkward one, and in the event of the examiner preferring to remain seated, necessitates the separation of his knees widely, so that the chair of the patient is between them. This posture is not only uncomfortable, but for obvious reasons undesirable. Moreover, the operator is not able to follow any sudden motion of the patient's head when seated in this manner, since he is working at arm's length. When the other position is employed, a slight motion of the arm enables the operator to so follow any sudden movement which the patient may make on account of fear or pain that the exactness of the manipulation is in no way disturbed.

The light should be placed, preferably, on the left of the examiner, and slightly above the horizontal plane passing through the ear to be examined. In this manner any manipulation of instruments with the right hand will not interfere with the rays passing from the lamp to the mirror.

---

[*] Burnett's System of Diseases of the Ear, Nose, and Throat, 1893, vol. i, p. 105.

The patient, surgeon, and source of light being satisfactorily arranged, it should be the invariable rule to examine the auricle, the entrance of the meatus, and the cartilaginous canal to as great a depth as possible before the speculum is introduced, as the speculum may conceal some pathological condition at the very entrance of the meatus unless this rule is followed. In order to examine the cartilaginous canal and to prepare for the insertion of the speculum, the auricle should be grasped firmly but lightly at its upper and posterior margin between the third and fourth fingers of the left hand, and traction should be made upward, backward, and outward. In examining the right ear the hand lies behind the auricle; in examining the left ear it lies above and anterior to it. In this manner a fairly good view of the external portion of the meatus is obtained, and any irregularities in size and shape may be noted as well as any deviation from the usual direction. The information thus derived enables the investigator to select a speculum of appropriate size, which should be grasped lightly between the thumb and index finger of the left hand, warmed over the lamp, and then introduced into the canal as lightly as possible. To effect this the operator holds the speculum between the thumb and index finger, grasping the auricle,

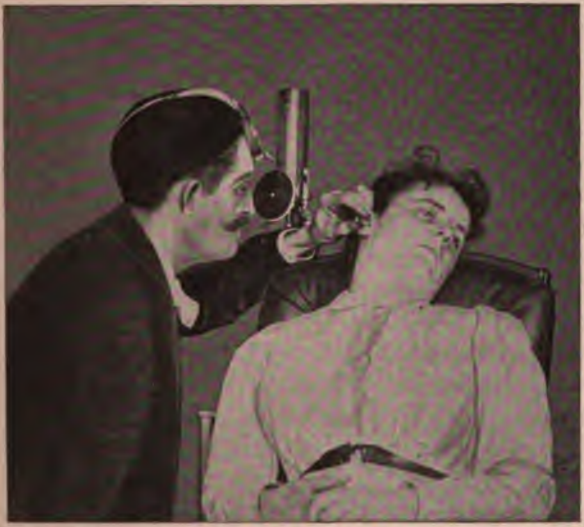


FIG. 38.—The ocular inspection of the membrana tympani, showing the position of the patient, the surgeon, the source of light, and the manner of holding the speculum.

as before, between the third and fourth fingers of the left hand. While the auricle is drawn upward, outward, and backward, the dilating instrument is gently introduced into the meatus, is advanced gradually by rotation upon its long axis, it being rolled, so to speak, between the thumb and index finger, while at the same time it is pushed inward. Care should be taken not to pass the instrument beyond the cartilaginous canal, since this is not only painful, but interferes with the mobility of the outer portion of the meatus, and hence limits the area exposed for inspection. The speculum must be of such a size that the walls of the canal are simply separated by it and not stretched, as this interferes with the mobility of the membranous portion of the canal and prevents it being so manipulated as to make its axis coincide with that of the bony meatus. When the speculum is too large the soft parts are so crowded in front of it that the full lumen of the speculum is not available and the field is narrowed in consequence.

The speculum having been properly inserted, the observer should first bring that part of the superior wall of the canal into view which lies just beyond the inner extremity of the speculum. This is done by carrying the thumb and index finger which hold the instrument downward, thus tilting the inner extremity upward. Having recognized the superior wall of the meatus, the anterior, inferior, and posterior walls are successively brought into view by causing the outer end of the speculum to describe a circle in the direction named, the fixed point being the inner extremity of the instrument. This manipulation is accomplished by a slight movement of the thumb and finger which grasp the outer end of the speculum, the digits being alternately flexed and then gradually extended until the extremity of the instrument has described a complete circle. In conducting this manipulation each wall of the meatus should be inspected throughout its entire extent, from the inner end of the speculum to where it joins the tympanic ring.

Attention should be paid during this procedure to the following points regarding the canal: Whether it is free throughout its entire length, or partially or completely obstructed. If the lumen is encroached upon, information should be obtained as to the nature of the obstruction, whether it be a foreign body accidentally or intentionally introduced, or whether it is made up of a mass of impacted secretion, whose source is the ceruminous glands of the meatus, or of epithelial débris, the result of an inflammatory process, or of a parasitic growth which has proliferated in this locality. On the other hand, the deeper portion of the canal may be filled with fluid, either pus, serum, mucus, or blood. Again, the lumen of the canal may be encroached upon only over a certain circumscribed area, in which case the probe determines the density of the obstruction—whether it is hard or soft, tender or anæsthetic, whether invested with normal epithelium or presenting a denuded surface. Its location should always be carefully noted, whether it is situated in the deeper portion of the canal or near the orifice. In other cases the canal may be narrowed uniformly throughout its entire extent. Here the density of the walls as determined by the probe is of service, as well as the appearance of the outer surface. None of these more evident abnormal conditions existing, the observer should in all cases note the condition of the integument lining the canal, determining whether it is dry and desquamating in places, or moist and reddened, or covered here and there with masses of dry secretion forming crusts upon the walls. Having critically observed these different physical conditions, the superior wall of the meatus should be followed inward, the angle of the speculum being gradually changed so as to bring the deeper portions into view until this aspect of the canal merges into the membrana flaccida. The outer end of the speculum being still further elevated, the eye next recognizes the epidermal covering of the membrana tympani and follows this until it passes quite abruptly into the inferior wall of the meatus. An examination in this manner—the superior wall being followed across the fundus of the meatus until the eye looks upon the inferior wall, and the posterior wall traced until it merges without a break into the anterior—demonstrates with certainty that the membrana tympani is present, and, if no solution in continuity has been observed, intact. This is the most satisfactory method of demonstrating that the membrana tympani is present and unbroken throughout its entire extent. Whenever there is a solution of continuity this regular outline must be broken. In some cases, where the membrane is almost completely destroyed and is replaced by cicatricial tissue which applies itself closely to the internal wall of the tympanum, a mistake may be made; this is scarcely possible, however, if an exhaustive examination is made, each wall being followed until it merges into the one directly opposite. When the membrana is extensively destroyed, as mentioned above, we find usually at some point along the posterior wall that the fundus of the canal is not continuous with this wall, but that there is a solution of continuity at the inner extremity, the epidermis not passing directly from the posterior wall of the canal to the promontory, but that a certain space is left between these two regions, the width of the hiatus being easily recognized by the practiced eye. I have given this as one of the early steps in conducting the examination, since the observer more readily analyzes appearances met with if the question of presence or almost complete destruction of the drum membrane has been settled before other points are considered.

We must next recognize certain landmarks at the fundus of the canal, which under normal conditions is occupied by the membrana tympani (Fig. 39). As the superior wall is followed inward, there will be seen just below the centre of the line marking its inner termination, a prominent projection, white or grayish white in color, having the appearance as though the soft parts covering it were pushed outward into the lumen of the canal by some firm body beneath. This projection is the short process of the malleus, and its position changes but little, no matter how much the entire ossicle may be displaced by rotation about the axis from alterations in tension of the intratympanic ligaments and muscles. Moreover, this portion of the ossicle is richly supplied with nutrient vessels, and even when there is extensive caries of the tympanic walls and of the ossicular chain, it usually escapes disintegration. Under normal conditions the short process of the malleus appears as a prominent point, about the size of a pinhead, varying in color from a chalky white to a grayish white or even pinkish white. Extending downward and somewhat backward from this point, through the middle of the membrane as far as its centre, the handle of the malleus is recognized. This process tapers gradually as it passes downward. At its lower extremity it is flattened slightly from without inward, and appears a little broader than just above its termination. The shaft of the malleus is slightly curvilinear in outline, the convexity being toward the meatus in the upper two thirds, while at the lower third it is directed inward and somewhat backward, lying more nearly in the plane of the membrane. The outline of the shaft, under normal conditions, appears somewhat darker than the surrounding membrane, its presence offering an obstruction to the rays of light illuminating the fundus of the canal. The outline of the shaft is not infrequently slightly pinkish instead of white, and occasionally one or two blood vessels may be recognized traversing the membrane close to the manubrium and parallel to it. This is particularly true if the speculum has remained in the canal for some time, and depends upon the venous congestion incident to the presence of the foreign body. The flattened termination of the manubrium at the centre of the membrane is known as the umbo. Under normal conditions the eye perceives a bright triangular area upon the surface of the membrane, extending from the umbo downward and forward to the periphery, the apex of the triangle lying at the umbo, while the base of the triangle does not extend to the periphery, but fades away gradually before it reaches this line. It is evident that if we imagine the malleus handle to be prolonged to the periphery of the membrane, this structure will be divided into two portions—one in front and the other behind the line, the posterior portion being the larger. If a horizontal line is drawn through the umbo to the anterior and posterior walls of the canal, these two segments will be again divided into two. For convenience in locating pathological appearances we conceive the drum membrane to be so divided, the segments being named the superior anterior, inferior anterior, inferior posterior, and superior posterior quadrants according to their situation. From the short process of the malleus two bands are observed, one running backward, the other in the opposite direction, to the periphery of the membrane. Of these, the posterior is the longer, the anterior being just barely seen under normal conditions owing to the proximity of the short process of the malleus to the upper anterior extremity of the tympanic ring, and because of the obliquity of the plane in which the membrane lies. These bands are called the anterior and posterior folds of the membrane. They are caused by the difference in tension between the membrana tensa below and the membrana flac-

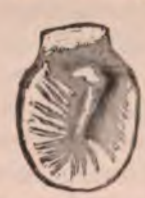


FIG. 39.—The normal membrana tympani (somewhat diagrammatic).

cida above. These bands are sometimes very well marked, while in other instances they are not distinct.

Between the short process of the malleus and the superior wall of the meatus the membrana tympani presents a distinctly triangular form, the apex of the triangle lying at the short process, from which point the sides of the triangle diverge until they are lost in the superior wall of the canal, into which they pass without any distinct line of demarcation. The sides of the triangle are clearly marked by a thickening along the lateral boundaries of this triangular area. This upper portion of the drum membrane is the membrana flaccida, or Shrapnell's membrane, and the fibres which form the sides of the triangle are known as Prussak's fibres. It will be remembered that the tympanic ring is wanting at Shrapnell's membrane, the curvilinear outline being completed by the free border of the outer lamella of the squamous plate of the temporal bone, which fills up the gap between the anterior and posterior limbs of the annulus. The name of Rivinian fissure or segment has been given to this dehiscence in the annulus tympanicus. It is also to be borne in mind that the lamina propria of the drum membrane is wanting over this area, the septum being completed by the tegumentary lining of the canal which passes downward over the Rivinian fissure, its epithelial layer being continued over the surface of the membrana tympani.

Having determined that the membrana tympani is intact, or, if any solution of continuity exists, the extent and location of the defect having been made out, the observer should next note the following physical properties of the membrana or of its remaining portion: 1. The color. 2. The lustre. 3. The structure. 4. The position.

The Color.—The normal membrane is of a pearly-white appearance, with a slightly bluish tinge over the entire membrana tensa; above the folds the parts may have a faint pinkish hue, even when in a healthy condition.

The Lustre.—The recognition of variations in the lustre of the drum membrane constitutes one of the most valuable aids in the diagnosis of aural affections. Normally the parts possess a peculiar sheen which can not be described in words, but is easily recognized when once seen. The triangular light spot has already been spoken of, and its persistence or absence, the variations in shape, position, and extent, and the presence of one or more bright points or light reflexes in other parts of the membrane, all furnish valuable information. The lustre may be diminished or may be entirely wanting, this latter condition always indicating a necrosis of the superficial epithelium.

The Structure.—Under this term we consider the deviations from the normal appearance resulting from changes in the various layers of the part under examination. In health the membrana vibrans is of uniform texture throughout, except at the periphery and at the umbo, in which localities it is somewhat thickened and consequently less translucent than elsewhere. The eye is also able to make out indistinctly the circular and radiating fibres as they cross one another, giving an appearance suggestive of a finely woven fabric. Under pathological conditions the membrana propria may undergo hypertrophy in places, in which case the uniformity of textural appearance will be lost and the affected areas will appear less translucent than the surrounding portion. The same effect is produced, but in a more marked degree, by calcareous deposits in the fibrous layer. These appear as opaque, lustreless white areas, with well-defined outlines. On the other hand, as the result of pressure, cicatrization after loss of substance, etc., the fibrous layer may be very thin or even wanting in certain localities. Here the membrane will be transparent, and through the thin septum the underlying structures within the tympanum may be easily recognized. The membrana flaccida, containing no lamina propria, does not exhibit the peculiar woven appearance characteristic of the larger segment of the drum membrane; its appearance is similar to that of the skin lining the adjacent part of the bony meatus, except that it is more delicate in structure. Owing to pathological changes it may become transparent and parchmentlike, or its thickness may be greatly increased.

The Position.—Normally, the drum membrane is inclined both in the horizontal and vertical planes. In addition to this it is drawn inward at the umbo on account of its intimate connection with the manubrium mallei. The inclination in two planes, together with the umbilication at the centre, gives rise to the light reflex, the rays illuminating this area alone being reflected directly back to the eye of the observer, without previously impinging upon the walls of the canal. Another result of the umbilication is to give to each segment of the membrana a slightly convex appearance when viewed from the canal, which is most marked in the upper and posterior quadrants. In the young child the inclination of the membrane in the horizontal plane, as viewed through the meatus, appears more pronounced than in adult life. This greater inclination is more apparent than real, depending upon the special conformation of the parts at birth. At this period, it will be remembered, the superior and inferior walls of the meatus are in contact, the superior wall lying upon the external surface of the squama while the bony meatus does not exist, being represented by a canal of fibrous tissue, especially well developed along the inferior wall.

Having reviewed the appearance of the membrane under normal conditions, we are now prepared to recognize variations caused by morbid processes. As the upper and posterior part is nearest the eye of the observer, and as this is the most extensive segment of the membrane, displacement of the entire membrane outward in this region is more apparent than elsewhere. If displacement be excessive the bulged posterior portion may overhang the anterior segment and partially or completely obscure it. Sometimes the effect is to obliterate in this region the line of demarcation between the canal wall and the drum membrane, giving to the fundus a narrow appearance. On the other hand, marked retraction obliterates the normal prominence of the upper and posterior segment and exaggerates the inclination of the upper part of the membrane in the horizontal plane, at the same time causing the inferior segment to appear more nearly perpendicular to the inferior wall of the canal. It also tends to exaggerate the apparent width of the drum membrane on account of the greater depth of the tympanum above and behind, which allows the membrana to move inward for a considerable distance, thus bringing the anterior segment into view. As seen through the speculum, this increase in the transverse diameter, especially of the inferior segment, is exceedingly well marked. The most valuable indication of retraction, however, is afforded by a careful inspection of the malleus handle. This prominent and easily recognizable landmark appears foreshortened in direct proportion to the degree of retraction, provided adhesions between it and the inner tympanic wall do not exist, and prevent it from assuming the usual position which it occupies when the pressure within the tympanic cavity is lowered. Another evidence of extreme retraction is the prominence of the curved margin of the tympanic ring, which can frequently be traced throughout its entire circumference when the membrane is displaced inward to a marked degree. It sometimes happens, owing to the presence of adhesions, that the handle of the malleus is not foreshortened; then the displacement of the segments of the drum membrane in front and behind the manubrium, together with the marked prominence of the annulus and the ease with which the intratympanic structures are seen, enable the observer to interpret the condition correctly. When the malleus handle is firmly bound down and the air within the tympanic cavity is rarefied, the anterior and posterior segments of the drum membrane collapse, and the manubrium appears as a prominent ridge between the sunken areas. In front, behind, and below this ridge there are deep pits or fossæ, where the more elastic membrane has been forced inward by the pressure of the air until it has impinged upon the inner tympanic wall. In children this condition is very prone to exist where adenoid vegetations are present. The appearance is not infrequently a source of error in diagnosis, being mistaken for a total destruction of the membrana vibrans and a subsequent dermoid transformation of the inner tympanic wall.

Obstacles to the Examination.—The description given of the technique of the inspection of the ear by means of reflected light, presupposes that an unimpeded view has been possible; occasionally, however, obstacles are encountered which render the inspection of the deeper parts difficult Here we may mention the presence of fine hairs in the meatus preventing a perfect illumination of the membrana tympani. In such an event the examiner, after the insertion of the speculum, will find it advisable to apply a little vaseline or wax to the hairy area by means of a cotton-tipped probe; by this procedure the hairs are made to adhere closely to the wall of the canal, and are prevented from interfering with the examination. If the orifice of the meatus is exceedingly narrow, either as the result of congenital malformation, cicatricial contraction, or an acute circumscribed inflammatory process, the examiner will do well to use an exceedingly small speculum. By tilting the instrument at various angles it will be possible to inspect the deeper parts over successive small areas until the necessary information has been obtained.

This is wiser than to attempt to use a large instrument which fits the canal closely, in the hope of obtaining a more extended field of view.

The prominence of the antero-inferior wall occasionally offers an obstacle to perfect inspection of the deeper parts; but here again the small speculum will enable the observer to see a more extended surface than a larger instrument, provided the auricle is drawn upward and backward sufficiently to permit the illumination of the parts beyond the obstructing canal wall. In the same manner, if the orifice of the meatus is almost closed, as the result of an acute inflammatory process, and the parts are excessively tender, it is possible, by exercising a little care, to introduce a small speculum beyond the inflamed area, and to obtain a view of the deep parts. It is to be remembered that no bony meatus exists at birth, and the membrana tympani lies superficially and in nearly the same plane as the superior wall of the canal, which is closely attached to the outer surface of the squama; hence, to obtain a clear view of the membrane, the auricle must be drawn downward and backward instead of upward and backward, as in the examination in an adult (Fig. 26).

In addition to what has already been said concerning the recognition of the various normal and pathological conditions, it is necessary to call attention to special portions demanding particular investigation; these are the periphery of the membrane, and that area lying above the level of the short process, the membrana flaccida. It is quite possible to recognize all the conditions enumerated in the preceding pages and yet to overlook a small perforation, unless the examiner, as a final step, inspects the entire outline of the annulus, following with the speculum the line of attachment of the membrane throughout its entire circumference. Again, that region situated above the short process of the malleus and the folds of the membrane demands careful attention, since it covers the articulation between the malleus and the incus, and that portion of the tympanum where the mucous lining is thrown into numerous folds as it passes from the bony walls of the cavity over the intratympanic ossicles and ligaments. It is not uncommon to find a minute perforation through the membrana flaccida, which might pass unrecognized unless special attention had been directed to the inspection of this locality. It should be borne in mind in this connection that we occasionally meet with a minute opening, just above the short process of the malleus. This was formerly supposed to be occasioned by the incomplete closure of the Rivinian segment. A small opening at this point is, according to Randall,* due to a pathological process, and there is no foundation for considering it a result of imperfect development. Under all circumstances both ears should be examined, although the patient may complain of but one. The importance of this is evident if the reader will recall the remarks already made in the chapter on physiology, concerning the interdependence of one organ upon that of the opposite side. It is also important, since any slight anomaly in the direction of the canal or in the position of the membrana tympani will probably exist on both sides, and a source of error in the interpretation of appearances found in the affected organ will thus be removed.

At this point we should consider the relation between the contents of the tympanum and the various quadrants of the tympanic membrane.

Fig. 12 represents the intratympanic structures and the inner wall of the middle ear, the ossicles lying in their normal position. A portion of the inferior and posterior wall of the canal is shown. The membrana tympani, with the exception of a small crescentic portion posteriorly, has been removed and the contents of each quadrant can be easily made out.

In the supero-posterior quadrant the long process of the incus is seen descending in a direction parallel to the manubrium mallei, lying behind it and at a deeper level in the tympanic cavity. The articulation of this process with the head of the stapes is also seen, together with the posterior crus of this latter ossicle, which passes upward and inward until it is lost in the oval niche. From the head of the stapes a delicate fibrous band is observed, which extends directly backward until it is lost from view behind the margin of the tympanic ring. This is the tendon of the stapedius muscle. The tip of the descending crus of the incus (and hence the incudo-stapedial articulation) may frequently lie at a considerable distance below the level of the short process of the malleus. On the other hand, and especially as the result of a pathological condition, this process of the incus may run almost horizontally inward, the processus lenticularis being hidden behind the supero-posterior margin of the bony ring. In such an event the stapes itself and the stapedius tendon are out of the range of vision. Another situation frequently occupied by this process of the incus is close to and just behind the posterior margin of the bony ring. It passes downward in a direction parallel to the posterior limb of the annulus, and is brought into view if the patient's head is turned away from the examiner, permitting the illuminating rays to pass behind the projecting margin of the ring. This position of the incus is usually the result of contraction of the stapedius muscle or of shortening of its tendon. Search with a delicate probe reveals the location of the crus of the incus, the instrument being easily hooked about it and drawing it into view. If firmly fixed, the division of the stapedius tendon or of dense adhesions passing backward from the posterior crus of the stapes releases it and brings it into the field of vision. The upper and posterior quadrant, since it contains structures so important to the function of audition, should always be closely examined, whether the membrana tympani is intact or partially destroyed. Frequently the attenuation of the membrana in this locality, either from cicatrization or atrophy, enables the observer to recognize the above-mentioned parts through it. This is particularly so when there is considerable retraction of the drum membrane, which then applies itself closely to the structures beneath.

---

* Trans Am. Otol. Society, 1894.

Below the incudo-stapedial articulation in the lower part of the supero-posterior quadrant, and encroaching to a greater or less extent upon the postero-inferior quadrant, is seen a deep niche the posterior boundary of which is hidden by the margin of the annulus tympanicus, while the anterior margin forms the postero-inferior boundary of the promontory. At this line the inner tympanic wall bends at almost a right angle, and the plane of the niche is directed backward and downward. The depression formed by this sudden bend is the niche of the round window. Sometimes it lies entirely behind the margin of the ring and out of the field of vision. The portion of the tympanic wall occupying the middle of the field of inspection is the promontory. It covers the first turn of the cochlea, and exhibits a convex surface which encroaches to a varying extent upon the the cavity of the tympanum. When this portion of the wall is unusually convex, and the niche of the round window can be seen, the projecting mass will occasionally be mistaken for an exostosis unless the possibility of its anomalous prominence is borne in mind. The region corresponding to the antero-inferior quadrant presents nothing demanding special notice, except that the tympanic opening of the Eustachian tube may encroach upon its upper part. In the majority of cases the tympanic orifice of the tube lies in the upper anterior quadrant and may be entirely concealed by the anterior border of the tympanic ring.

When the membrana vibrans is absent it is possible to pass a delicate probe, bent at a right angle at the tip, upward into the vault of the tympanum, both in front and behind the short process of the malleus, the angular portion disappearing completely in the upper tympanic space. Traction outward causes the bent part of the probe to press upon the inner extremity of the superior wall of the canal, and the instrument can not be removed by traction directly outward, it being necessary first to disengage its tympanic extremity from the inner margin of the superior wall of the meatus.

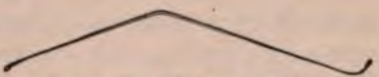


FIG. 40.—Middle ear probe.

As the result of caries, the superior wall of the meatus close to the tympanum may be destroyed, bringing into view a portion of the head of the malleus and the adjacent part of the incus, or, where the ossicles have been destroyed or displaced, the upper part of the inner tympanic wall lies exposed. We then see distinctly the pelvis ovalis, and just above this the wall of the aquæductus Fallopii arching over it. If this last structure has been involved in the carious process, impact of the probe may cause twitching of the facial muscles, owing to mechanical irritation of the seventh nerve.

Naturally, in inspecting the tympanic cavity where the membrana tympani has been destroyed as the result of disease, or where a flap has been reflected for the purpose of exploration, the parts which can be brought into view will largely depend both upon the position in which the head of the patient is placed and upon the correct manipulation of the speculum, so that areas hidden from the direct line of vision by the overhanging margins of the inner extremity of the canal may be illuminated by rays from the head mirror.

Botey * has advised the use of small mirrors, which are to be introduced into the tympanic cavity for the purpose of inspecting the parts lying beyond the direct line of vision; but the procedure has met with little success. Blake † suggested the same method long ago, and made a practical application of it to determine the attachment of a growth springing from the inner extremity of the superior wall of the canal.

In the preceding pages we have spoken of the physical characteristics revealed by ocular inspection. The reader is not to understand, however, that the eye alone is to be used; a delicate probe is of great service in settling a doubtful appearance, and the value of its use can not be too strongly advocated. Where it seems unadvisable to use a metal instrument for fear of injuring the delicate structures, a very satisfactory substitute is found in the use of what may be termed a cotton probe, constructed as follows: A small bit of cotton is wound tightly about the extremity of a delicate cotton holder (Fig. 41) in such a manner that the cotton shall project for about a quarter of an inch beyond the end of the shaft, it being wound so tightly as to offer considerable resistance upon pressure, and constituting really a prolongation of the probe. This cotton tip can be bent at any desired angle, and is firm enough to retain its shape, and yet not so firm as to injure the delicate structures encountered. It is less disagreeable to the patient than a metallic instrument, while it is of equal service to the examiner. An instrument constructed in this manner can be introduced through a small perforation in the membrana tympani, or into a sinus in front of or behind the short process, and be carried into the upper part of the cavity. Tactile impressions resulting from the proper manipulation of the instrument afford valuable information.

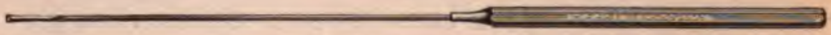


FIG. 41.—Cotton holder.

The mobility of the membrana and ossicles should be determined as the next step of the examination. This may be

---

* Rev. mens. de laryngol., vol. x, p. 681.

† Trans. Am. Otol. Society, 1872.

done by making use of Siegle's speculum (Fig. 42). It consists of a hard-rubber speculum, the wider extremity of which is screwed tightly into one end of a short cylinder of the same material as the speculum, while the extremity introduced into the canal is covered with a small bit of rubber tubing to effect an air-tight closure of the meatus. The opposite end of the cylinder is closed by a cap which makes an angle of forty-five degrees with the axis of the instrument. In the centre of this cap is an opening covered with glass. Upon one side of this cylindrical chamber is an opening into which a short tube is screwed. The free extremity of the tube is connected with a small air pump, bellows, or atomizer bulb by a short piece of flexible-rubber tubing.

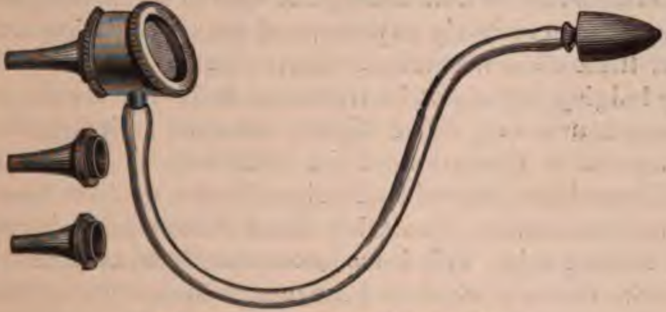


FIG. 42.—Siegle's pneumatic speculum.

After the speculum has been carefully inserted into the external auditory meatus, the air in the canal can be exhausted by means of the small air pump or rubber bulb with which the instrument is provided, or the flexible tube may be held between the lips and the air withdrawn in this manner. The density of the air in the meatus can be increased if desired by reversing the direction of the current. The glass in the outer extremity of the instrument permits the examiner to watch the different motions of the membrana tympani and ossicles, caused by the alternate condensation and rarefaction of the air in the canal. Were the glass at right angles to the axis of the speculum, the reflection of the illuminating rays would interfere with the view of the deeper parts, but this is avoided if it is placed at an acute angle. Under normal conditions the drum membrane moves outward each time the air in the canal is rarefied, and passes in the opposite direction when condensation is effected, the motion being most evident in the postero-superior quadrant. The malleus at the same time rotates about the axis band, the short process remaining almost immovable, while the long process participates in the outward excursion of the membrane. Areas over which the membrane is adherent to the inner tympanic wall are easily recognized, since they are not affected by changes in the air pressure. It is also important to note closely the motion of the malleus, for if bound down at its tip any outward excursion is impossible. Under these circumstances it either remains fixed, the membrane bulging beyond it in front and behind, when the air is exhausted, or it may move slightly outward at its upper part when there is relaxation of the structures in this locality. Sometimes intratympanic adhesions fix the malleus in such a manner that, instead of rotating about the axis band, it rotates upon its long axis. This is frequently observed in cases where the entire ossicular chain and the membrana are drawn inward as a whole by adhesions, the membrane, therefore, giving no marked evidence of malposition except that it appears farther from the entrance of the meatus than usual. When the excursions of the malleus are changed in character, so that rotation takes place about the long axis of the ossicle, we are warranted in assuming the presence of extensive intratympanic adhesions, together with some relaxation at the malleo-incudal articulation.

The use of a magnifying lens in connection with the pneumatic speculum is seldom of advantage, the unaided eye distinguishing variations from the normal quite as readily as when a lens is used.

Our physical examination has thus far been confined to those parts of the conducting mechanism which can be investigated by sight and by touch. We now have to call to our aid the sense of hearing for the examination of parts not accessible to ocular inspection. These parts are the Eustachian tube and the tympanic cavity.

Inflation of the Tympanum.—Since the tympanum communicates with the pharyngeal vault through the Eustachian tube, a sudden condensation of air in the vault of the pharynx will cause a corresponding increase in air pressure in the middle ear, provided the Eustachian tube is open. The tympanum is separated from the external meatus only by the thin membrana tympani, and the examiner, by inserting a flexible tube into the meatus of the patient while the other extremity is inserted into his own auditory canal, is able to recognize the moment when the air enters the tympanum, by its impact upon this delicate partition. The sound produced under normal conditions when the tympanum is suddenly inflated we may denominate, for convenience, the sound of impact. It is of sharp, metallic character, and is due to the stretching of the membrana tympani by the sudden condensation of the air within the middle ear. This sound seems to originate in the ear of the observer on account of the extreme thinness of the interposed partition, and the direct conveyance of the sound waves to his ear. Under normal conditions but a single sharp metallic click or snap is heard. This may be followed later by a similar sound of lower pitch and of less intensity, due to the return of the membrana to a condition of equilibrium in virtue of its elasticity. A familiarity with these signs in health enables the observer to interpret correctly the significance of any modification in their character due to pathological conditions. It is sometimes stated that auscultation is a procedure of little diagnostic value, but I can only say that the otologist who would take this ground, might be compared with a physician who would consider himself able to judge of intrathoracic conditions without availing himself of auscultation of the chest. Auscultation certainly affords us a valuable means of recognizing certain conditions within the tympanum and Eustachian tube, if practiced sufficiently long to enable one to interpret the significance of the various sounds heard.

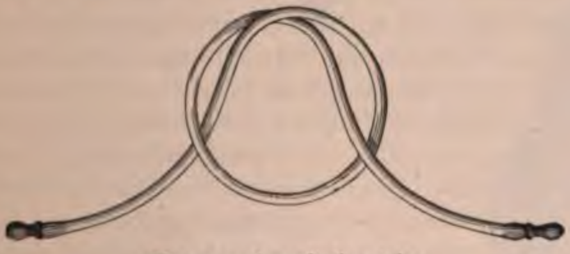


FIG. 43.—Auscultation tube.

Methods of Inflation.—The earliest method of inflation of the middle ear is that which bears the name of its discoverer, Valsalva. It is executed by the patient compressing the alæ nasi between the thumb and finger of one hand, thus closing the nostrils; at the same time the mouth is closed and the attempt is made to force air through the nostrils—in other words, to blow the nose. The result is that the air is forced into the tympanum, since all other avenues of exit are closed. The procedure is frequently valuable as a diagnostic measure, as the surgeon can observe the effect of the increased intratympanic pressure upon the drum membrane, by an inspection of the part while the patient performs the inflation. Depending as it does upon the patient himself for its efficiency, this process possesses but little therapeutic value.

The most universally employed method of inflating the middle ear is that first brought into prominence by Politzer,* and bearing his name. To force air through the Eustachian tube by this procedure, the surgeon makes use of a balloon-shaped rubber bulb, to which a tube of the same material is attached; the sudden compression of the bulb by the hand, expels the air through the free end of the tube with considerable force. This extremity of the tube is provided with a hard-rubber tip, so shaped that it may be inserted into the nostril of the patient, or in some instances it is conical in form so as to occlude the nostril. In inflating with this instrument, the nose piece is held in position by the fingers of the surgeon's left hand, the other nostril being occluded at the same time by compressing the alæ of both sides; the patient is then directed to take a small quantity of water into the mouth, and to swallow it at a given signal. Coincident with the act of deglutition the physician compresses the bulb, which he holds in the right hand, by quickly and firmly closing the fingers upon it, thus driving the air within it into the pharyngeal vault, and from thence into the tympanic cavities through the Eustachian tubes. The action of swallowing shuts off the pharyngeal vault completely from the oro-phar-

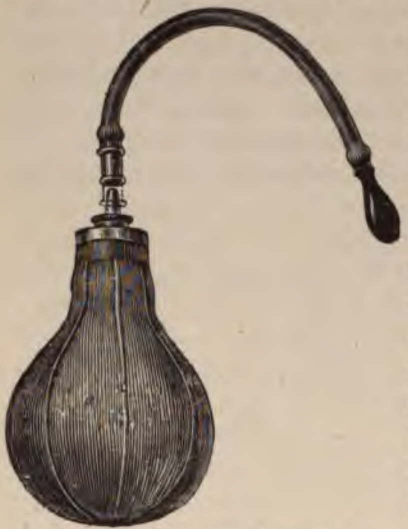


FIG. 44.—Politzer's air-bag.

---

* Wien. med. Woch., 1863, No. 6.

ynx, by the elevation of the soft palate, the muscular action effecting this, at the same time serving to render the tube more permeable, in the manner already described in considering the function of the tubal muscles. Various modifications of this procedure have been devised, the success depending largely upon the intelligent co-operation of the patient. The act of swallowing must be coincident with the compression of the inflating bulb; otherwise, the naso-pharyngeal space will not be shut off, and an imperfect operation will be the result. When this occurs, the operator not only fails to carry out the measure intended, but occasions great discomfort to the patient, and occasionally to himself, for the sudden entrance of the air into the oro-pharynx forces the water which the patient is attempting to swallow, either into the larynx, bringing on a severe seizure of coughing, or out of his mouth, deluging himself and operator as well.

The modifications of the Politzer method have been designed to obviate such accidents. One of the best is to direct the patient to close his lips and then puff out the cheeks, as though trying to whistle with the mouth closed. Another fairly successful method is to repeat rapidly the letter K, or any syllable containing the K sound. Either of these procedures, causing an elevation of the soft palate, effects a fairly perfect closure of the pharyngeal vault. These modifications are of particular convenience in children, and render the operation much less uncomfortable. In infants the act of crying produces sufficient closure of the naso-pharygneal space to allow of a successful inflation of the middle ear, if the air bag is forcibly compressed while the child is crying.

There can be no question of the value of Politzer's method both as a diagnostic and therapeutic procedure, but its use should, I think, be restricted to certain cases, and it should not be adopted to the exclusion of catheterization of the tube.

A few words will not be out of place here regarding the selection of a proper inflating bulb, or Politzer bag, and of a proper tip for the instrument. The error usually made is to choose an unnecessarily large bag. A large instrument is cumbersome and at the same time less efficient, since it can not be so grasped that the hand is able to compress it quickly. The lumen of the delivery tube is frequently so small in proportion to the size of the bag, that when a sudden effort at compression is made, very little air is forced out, the tension in the bulb almost immediately reaching such a degree that further compression is impossible. The use of a small bulb, of not more than four ounces' capacity, is attended with more satisfactory results; the instrument can be easily held in the palm of the hand, so that the fingers encircle it, and can be almost completely emptied when the hand is quickly closed upon it. The actual air pressure obtainable with a bulb of moderate size is greater than with one of large dimensions. It is immaterial whether the air bag is provided with a valve which allows the entrance of air, but closes when the bulb is compressed, or whether it has but a single opening, in which case the free end must be removed from the nostril after each act of inflation. When this last form of bag is employed it must be removed from the nostril before the pressure upon the bag is relaxed; otherwise, the mucus from the nasal cavity will be sucked up into the tube. To prevent this accident it is also important that the tip be wiped immediately after removal, either with cotton or with a towel, and before allowing the bag to refill. It is more convenient certainly to use a bag provided with a valve, although even here, if the nose piece is allowed to remain in position, a certain amount of mucus may be aspirated from the nasal cavity. The objection to the valve lies in the fact that it is liable to get out of order. This difficulty may be obviated by cutting a hole in the side of the ordinary bag, and covering the opening with the hand during the act of compression; as the fingers are relaxed it is uncovered, thus allowing the balloon to fill readily. This is certainly more simple than any automatic valve, and demands only a little attention on the part of the operator to see that perfect closure of the opening is effected at each act of inflation. Personally, I often use a very small bulb of a capacity of about two ounces, such as is supplied with the ordinary hand-ball nasal atomizer. The valves in these instruments are fairly well made, and do not get out of order readily. The one which I prefer has two valves, one allowing the air to enter at the distal end of the bulb, while at the same time a valve at the opposite extremity closes the channel between the bulb and the nasal cavity of the patient, preventing the entrance of mucus. This small bulb is also particularly adapted for use with the catheter, it being only necessary to change the tip.

Regarding the particular form of tip suitable for insertion into the nostril, individual preference will probably be the best guide. Many advocate the use of a small, curved hard-rubber tip. This tube is inserted into the inferior meatus, where it is held between the fingers and thumb of the left hand, which at the same time compress the alæ nasi so tightly as to allow no air to escape. I have never been able to use this instrument to my own satisfaction, although there is no question that it is perfectly efficient in other hands. The objection to its use is that the introduction of the tube into the nostril may be painful, if the septum is considerably deflected, and even when the greatest care is used, slight hæmorrhage may follow the procedure. If this form of tip is chosen, care should be taken that its calibre is ample, permitting a large volume of air to pass through it. As the instrument is usually sold in the shops, the bore is very small in comparison with the external diameter of the tube. It is also wise to cover the end of the tube to be introduced into the inferior meatus with a piece of thin rubber tubing, as an abrasion of the nasal mucous membrane is less liable to be caused if this is done.

For my own use I prefer a conical tip, which occludes the anterior nasal opening perfectly by the coaptation of its surface with the soft walls of the opening into which it is inserted. This conical tip may be constructed either of glass, hard rubber, or aluminium, and care should be taken that the opening through it is of sufficient size to allow a free passage of the air when sudden condensation is effected. In children this conical tip is unquestionably more effectual and more easily manipulated than the one previously mentioned.

Catheterization of the Eustachian Tube.—By this manipulation the surgeon directs a current of air into the tympanum of one side or the other, by means of a canula, which is passed through the nasal passages into the vault of the pharynx and inserted directly into the Eustachian orifice.

Before giving a detailed description of the method of introducing the instrument, a few words may be said concerning the catheter itself (Fig. 45). It consists of a tube of either hard rubber, pure or coin silver, or of German silver, about eight inches long, bent in the arc of a circle at one extremity, while at the other it is expanded into an elongated funnel,

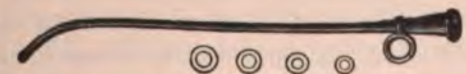


FIG. 45.—The Eustachian catheter.

a pathological condition, this process of the incus may run almost horizontally inward, the processus lenticularis being hidden behind the supero-posterior margin of the bony ring. In such an event the stapes itself and the stapedius tendon are out of the range of vision. Another situation frequently occupied by this process of the incus is close to and just behind the posterior margin of the bony ring. It passes downward in a direction parallel to the posterior limb of the annulus, and is brought into view if the patient's head is turned away from the examiner, permitting the illuminating rays to pass behind the projecting margin of the ring. This position of the incus is usually the result of contraction of the stapedius muscle or of shortening of its tendon. Search with a delicate probe reveals the location of the crus of the incus, the instrument being easily hooked about it and drawing it into view. If firmly fixed, the division of the stapedius tendon or of dense adhesions passing backward from the posterior crus of the stapes releases it and brings it into the field of vision. The upper and posterior quadrant, since it contains structures so important to the function of audition, should always be closely examined, whether the membrana tympani is intact or partially destroyed. Frequently the attenuation of the membrana in this locality, either from cicatrization or atrophy, enables the observer to recognize the above-mentioned parts through it. This is particularly so when there is considerable retraction of the drum membrane, which then applies itself closely to the structures beneath.

Below the incudo-stapedial articulation in the lower part of the supero-posterior quadrant, and encroaching to a greater or less extent upon the postero-inferior quadrant, is seen a deep niche the posterior boundary of which is hidden by the margin of the annulus tympanicus, while the anterior margin forms the postero-inferior boundary of the promontory. At this line the inner tympanic wall bends at almost a right angle, and the plane of the niche is directed backward and downward. The depression formed by this sudden bend is the niche of the round window. Sometimes it lies entirely behind the margin of the ring and out of the field of vision. The portion of the tympanic wall occupying the middle of the field of inspection is the promontory. It covers the first turn of the cochlea, and exhibits a convex surface which encroaches to a varying extent upon the the cavity of the tympanum. When this portion of the wall is unusually convex, and the niche of the round window can be seen, the projecting mass will occasionally be mistaken for an exostosis unless the possibility of its anomalous prominence is borne in mind. The region corresponding to the antero-inferior quadrant presents nothing demanding special notice, except that the tympanic opening of the Eustachian tube may encroach upon its upper part. In the majority of cases the tympanic orifice of the tube lies in the upper anterior quadrant and may be entirely concealed by the anterior border of the tympanic ring.

When the membrana vibrans is absent it is possible to pass a delicate probe, bent at a right angle at the tip, upward into the vault of the tympanum, both in front and behind the short process of the malleus, the angular portion disappearing completely in the upper tympanic space. Traction outward causes the bent part of the probe to press upon the inner extremity of the superior wall of the canal, and the instrument can not be removed by traction directly outward, it being necessary first to disengage its tympanic extremity from the inner margin of the superior wall of the meatus.

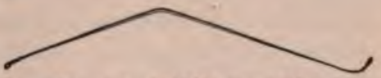


FIG. 40.—Middle ear probe.

As the result of caries, the superior wall of the meatus close to the tympanum may be destroyed, bringing into view a portion of the head of the malleus and the adjacent part of the incus, or, where the ossicles have been destroyed or displaced, the upper part of the inner tympanic wall lies exposed. We then see distinctly the pelvis ovalis, and just above this the wall of the aquæductus Fallopii arching over it. If this last structure has been involved in the carious process, impact of the probe may cause twitching of the facial muscles, owing to mechanical irritation of the seventh nerve.

Naturally, in inspecting the tympanic cavity where the membrana tympani has been destroyed as the result of disease, or where a flap has been reflected for the purpose of exploration, the parts which can be brought into view will largely depend both upon the position in which the head of the patient is placed and upon the correct manipulation of the speculum, so that areas hidden from the direct line of vision the bulb, without any motion being imparted to the catheter when it is once in position. When this apparatus is used the hard-rubber tube is fitted into the catheter before the instrument is introduced into the nose, the small size of bulb rendering it possible to grasp this in the palm of the hand, while the fingers of the same hand hold the catheter and manipulate it during its passage through the nasal cavity (Figs. 46 and 47). This allows of great freedom of manipulation, on account of the length of the tube which joins the catheter to the bulb. After the catheter is once in place the fingers of the left hand fix it, while with the right hand the surgeon compresses the bulb as many times as may be necessary. No motion is communicated to the instrument as the bulb is emptied, and no discomfort attends the operation. Certainly from a humane point of view this method is to be preferred; and it may also be said that since the mechanical irritation is reduced to a minimum the therapeutic value is also greater.

Lucae* advises the interposition of an elastic bulb between the inflating bag and the catheter to serve as a receiver, which is filled by the compression of the inflating bag. The elasticity of this second bulb permits of the introduction of a continuous current of air into the tympanum. It has never in my experience seemed necessary that the current of air should be continuous, and for diagnostic purposes certainly, it would be of less value than an intermittent current.

Many Continental otologists advocate the use of a higher air pressure than can be obtained by any of the above instruments, and employ some form of air pump to secure the proper amount of tension. In such an instrument the air is forced by the pump into a large receiver, provided with a gauge for registering the degree of condensation. The Eustachian catheter is connected with this receiver by means of a flexible tube, and the air is allowed to escape through the instrument by means of a properly adjusted cut-off.

When the Eustachian tube is so much obstructed that catheter inflation is impossible with the ordinary air bag, some method should be employed to determine the exact nature of the obstruction, rather than to attempt to perform inflation with very high air pressure. The same remark will apply to the use of any form of foot bellows for a similar purpose. Regarding all of these devices, it should be borne in mind that, as a diagnostic measure, considerable information is gained by estimating the amount of force necessary to empty the bag by compressing it in the palm, in order to secure a free entrance of air into the tympanum, as evidenced by auscultatory signs. The hand and ear of the operator then act together, allowing him to interpret the relation between the intensity of any particular sound heard, and the force necessary to secure the degree of pressure requisite to force the air into the tympanum and produce the sound.

---

* Archiv für Ohrenheilk., vol. ii, p. 308.

An appropriate catheter and inflating apparatus having been selected, the next step is the technique of inserting the instrument. The plan which seems most simple will be first described, after which other methods will be detailed.

The inflating bulb is held in the palm of the right hand, while the catheter, having been properly connected with it, is grasped lightly between the thumb and index and middle fingers of this hand, much as a pen is held. The shaft of the instrument points directly upward, while the curved pharyngeal portion lies in the horizontal plane, the orifice of the catheter looking forward. The patient should be seated in a chair with a high back, and the head should be inclined forward slightly, while at the same time he should be directed to close the lips tightly and breathe slowly and quietly through the nostrils. The operator, either standing or sitting at the right of the pa-

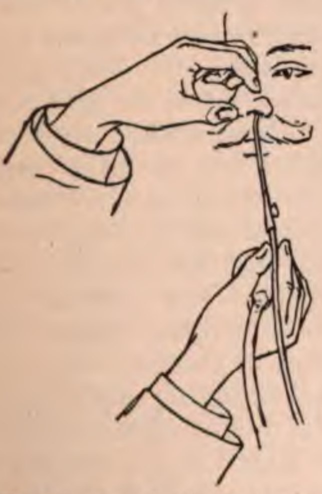


FIG. 46.—Introduction of the Eustachian catheter (first step).

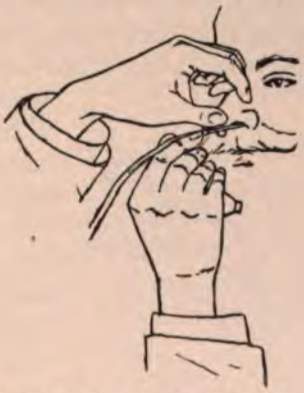


FIG. 47.—Introduction of the Eustachian catheter (second step).

tient, tilts the tip of the patient's nose upward with the ball of the left thumb, the index and middle fingers resting upon the nose just below the bridge. From this moment the left hand is not removed from the patient's nose until inflation has been accomplished and the catheter has been removed. The tip of the nose being elevated, the extremity of the catheter is introduced into the nostril (see Fig. 46); as soon as the instrument has passed the slight ridge at the nasal orifice the operator carries the hand holding the instrument upward until the catheter assumes a horizontal position. In this position, with the tip kept constantly upon the floor of the nasal cavity, the catheter is passed directly backward through the inferior meatus until the posterior pharyngeal wall is encountered (Fig, 47); it is then drawn forward about three eighths or one fourth of an inch, and, remembering that the guide ring on the shaft indicates the direction in which the pharyngeal extremity points, the instrument is rotated upon its long axis until the ring points almost directly outward toward the side to be inflated. The hand is then elevated a little and carried slightly toward the opposite ear, causing the pharyngeal extremity of the instrument to descend, and at the same time to press lightly against the lateral pharyngeal wall. By drawing the catheter a little outward, the tip will be felt to impinge upon the posterior lip of the tube; it is to be drawn over this, the tip being turned slightly downward, if necessary, to effect this without undue force. As soon as the operator knows by the sense of touch that the prominent posterior lip has been passed, the catheter is rotated upon its long axis until the guide ring points upward and outward toward the ear, while at the same time the outer extremity of the instrument is moved toward the opposite side, thus pushing the pharyngeal extremity well into the mouth of the tube. When carefully placed, the sense of fixation imparted to the hand is unmistakable. At this juncture the left thumb is moved so as to pass beneath the catheter and support it. The instrument is thus held firmly against the margin of the nostril, by the thumb below and the first three fingers, resting upon the

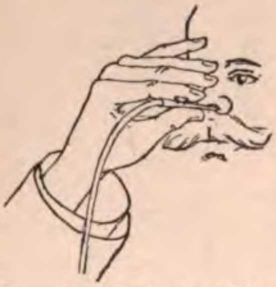


FIG. 48.—Introduction of the Eustachian catheter (the instrument fixed in the mouth of the tube).

bridge of the nose, above (Fig. 48); at the same time the tip of the nose is pressed upward as before. The right hand is now free to compress the bulb, forcing the air through the catheter into the middle ear, its entrance being recognized by sounds heard through the auscultation tube.

As already stated, the value of auscultation for diagnostic purposes can not be overestimated, and the catheter is much superior to other methods of inflation when the operation is performed as a diagnostic measure only. The amount of manual pressure necessary to force the air into the tympanum is also of importance in determining the degree of obstruction present, and this may be roughly estimated by the operator with each act of compressing the bulb. The various sounds produced afford exact information as to the physical condition of the mouth of the tube, of the tubal canal, and of the tympanum. These advantages are not offered by the Politzer method of inflation, since the efficiency of the procedure depends entirely upon the ability of the patient to close the naso-pharyngeal space completely at the proper moment. In catheterization the operator has the entire control of the procedure, and from knowledge derived by the sense of touch as to the exact location of the catheter, and by an estimate of the force employed during the act of inflation, he is able to derive valuable information from the various auscultatory sounds elicited during the experiment.

Auscultatory Sounds.—We may consider that the sounds heard through the auscultation tube are produced either at the pharyngeal orifice of the tube, or within the lumen of the canal, or within the tympanum. Frequently the ear analyzes the impression made upon it during such an examination, resolving the combination of sounds heard, into the several simple sounds produced at each of these locations.

The determination of the point at which a given sound is generated consists in measuring its intensity or its proximity to the ear of the examiner. Since the tympanum of the patient is separated from the lumen of the diagnosis tube simply by the drum membrane, any sound produced by the air entering the tympanum will appear to originate in the ear of the examiner. We also remember that, on entering the tympanum, the current passes from a narrow canal into a cavity of comparatively large size, and we should expect that its character would be modified by this change in the physical conditions, so that the pitch would be lowered and the quality softened.

On the other hand, sounds originating in the Eustachian canal would be of higher pitch, but would impress the listener as though they came from a greater distance from his ear than the tympanic sounds. Auscultation sounds originating in the naso-pharynx or at the pharyngeal orifice of the tube will seem still more distant, being heard quite as well with the open ear as through the auscultation tube.

The Normal Tympanic Bruit.—With the parts in a normal condition the surgeon hears with each compression of the bulb of the inflating apparatus a soft, dry, blowing sound, together with a slight but distinct percussion sound due to the impact of the current of air upon the drum membrane. This last is compared by Deleau * to drops of rain as they fall upon foliage in the forest during a shower. The "blowing sound" is produced by the passage of the aërial current through the catheter and Eustachian tube into the cavity of the tympanum; the "impact sound," by the obstruction offered by the membrana tympani to the farther progress of the air. With the membrane in a proper position and under normal tension, this last sound is but slightly marked, and may be so indistinct as to be entirely overlooked. It is possible, however, with care, to make out the tympanic, tubal, and pharyngeal components of the auscultation sound in almost every instance. We have next to examine the variations which the normal auscultation sound undergoes when the various parts are not in a condition of health. We will consider these according to the special region in which they arise.

1. *Tympanic Sounds.*—(*a*) An exaggeration of the "impact sound" indicates a considerable displacement outward of the membrane under the influence of the increased tympanic pressure. Hence the membrane must have been retracted, occupying an abnormal position—a fact already determined by previous speculum examination; or, if occupying a normal position, it must have been so relaxed as to admit of considerable outward displacement by the aërial condensation. If this last condition exists a secondary sound will be heard, as the hand holding the bulb relaxes, thus allowing the pressure

---

* Acad. de Sci., Dec. 7, 1829.

in the middle ear to diminish, by the escape of the air from the tympanum through the tube into the pharyngeal vault. The amount of air forced backward in this way, and consequently the intensity of this secondary sound, will depend upon the resiliency of the membrana tympani and the exactness with which the catheter fits the pharyngeal orifice. This secondary sound is sharp and similar to the original "impact sound," but less intense.

Sounds having their origin within the tympanum are heard so distinctly that those not accustomed to the use of the auscultation tube will frequently describe them as originating within their own ear.

(*b*) If now the tympanic cavity is filled with fluid the normal "blowing" and "impact" sounds undergo a change, so that a rough bruit is observed in place of the "blowing sound," accompanied and followed by a series of sharp crackling râles following each other at irregular intervals, and persisting for a short period as the inflating bulb is allowed to refill. This rattling appears to be in the ear of the examiner, and conveys the impression of a current of air being driven through a collection of fluid. The quality of these râles gives some hint as to the nature of the fluid. Crepitation of a fine, high-pitched character is heard when the fluid is watery, but the râles are coarse, low-pitched, and bubbling when the liquid is thick and viscid and adheres to the walls of the cavity. These distinctions are of but little importance, as the exact nature of the fluid is of no moment. It must also be remembered that even if fluid is present, it may lie out of the course of the current of air which enters the cavity, and the auscultation sound may afford no evidence of its presence.

(*c*) When the cavity of the tympanum is completely filled with fluid no crepitation is heard, as the air fails to enter the middle ear at all, and the normal "blowing sound" is also wanting. The "impact sound," however, is heard as the current of air enters the tube and impinges upon the fluid contained in the tympanum. The percussion sound, however, loses its sharp character, appearing indistinct, distant, and low-pitched.

(*d*) Any solution of continuity in the drum membrane is easily discovered upon forcing air through the Eustachian tube, provided the opening through the membrana is not completely shut off from the Eustachian canal by adhesions. The character varies with the size of the opening, being high-pitched and whistling when this is small, and of a blowing quality when the area destroyed is greater. With extensive destruction of the membrana the air is felt to enter the canal of the examiner and to impinge upon the walls of the meatus. The pitch of the note heard when the perforation is of moderate size will depend somewhat upon the thickness of its edges. Where the drum membrane is greatly swollen the edges do not vibrate freely and the sound is rather low-pitched. Where the thickening is not excessive, and especially if the membrane is fairly tense, a high-pitched note, known as the "perforation whistle," is heard.

(*e*) Certain sounds comparable to those heard when two moist surfaces are forcibly separated are frequently perceived upon inflation, and, from their apparent proximity to the ear of the examiner, evidently originate within the tympanic cavity. They are caused by the separation of the membrana from the inner tympanic wall, by the act of inflation, and are met with in cases where slight hypersecretion has taken place, allowing the two opposing surfaces to adhere. Occasionally these signs indicate the rupture of newly formed adhesions.

(*f*) When the middle ear is the seat of adhesive inflammation, which diminishes the size of the cavity by drawing the drum membrane inward, or when this structure itself is thickened and rigid from connective-tissue hyperplasia or from calcareous deposits, or where the tympanic orifice of the tube has been greatly narrowed, the tympanic factor of the bruit is practically lost, and the sound seems distant. This is observed most frequently in patients of advanced years.

2. *Tubal Sounds.*—In passing through the Eustachian canal the column of air is thrown into vibration, producing sounds which vary in character according to the patency of the passage, the condition of the walls, and the presence or absence of moisture. When the air is not heard to enter the tympanum, but the listener is conscious of a distant harsh blowing sound with each act of inflation, the catheter being correctly placed, but one interpretation can be made of the sign—it must indicate stenosis of the channel. The location of the obstruction is determined by observing the relative distance at which the sound appears to be from the ear of the examiner.

It approximates more nearly to the pure pharyngeal sound according as the barrier is located nearer this orifice. When the bruit is fairly constant in quality and intensity, the narrowing may be looked upon as depending upon some organic change in the tubal walls.

On the other hand, if its character changes with each act of compression of the air bag, then it is probable that the lumen of the tube is closed either by a plug of secretion or by tumefaction of the lining membrane. In the first instance the listener hears a harsh, moist, rasping sound, the pitch of which varies each time the air is forced inward, while occasionally the current will be heard to rush into the middle ear. This is caused by the momentary displacement of a mass of tenacious mucus which occludes the channel, permitting the air to enter. Prolonged inflation usually dislodges the obstruction and allows the current to enter the tympanum with each compression of the bulb.

When the tube is narrowed in calibre at any point by slight swelling or by a hyperplastic process, the blowing sound is of higher pitch, according to the degree to which the channel is narrowed, being of the squeaking or whistling character when the stenosis is nearly complete. When due to a hyperplastic process the sound varies but little as inflation continues, while if it depends simply upon swelling of the walls of the passage, the mucous membrane being at the same time moist, the bruit changes considerably in quality as the operation is continued, moist, crackling, or snapping sounds being heard from time to time, which modify the high-pitched, whistling note. The sensation of proximity to the observer is wanting, and this fact indicates the tubal origin.

When the walls of the tube are in contact, as the result of œdema, the air frequently fails to enter the passage when an attempt is made to compress the bulb, the catheter, if properly located, seeming to be completely occluded. A slight movement of the instrument and repeated efforts at inflation produces a distant clicking noise, followed by a high-pitched whistle, and the air is felt to rush into the middle ear suddenly. This phenomenon repeats itself during the operation, the air entering the tympanum only after the bulb has been compressed several times, and then but in small quantity.

It is scarcely necessary to call attention to the signs observed where the tube is abnormally patent; one need only remember that the intensity of the tympanic sound must be greater if the tube is of wide calibre than if it is narrowed. The same is true of the intensity of the tubal sound itself. At the same time there will be no resistance to compression of the bulb.

3. *Pharyngeal Sounds.*—These sounds are easily recognized by their variable character; they are heard also quite as well through the air as through the diagnosis tube. Even when a perfect inflation is made under normal conditions a soft, indistinct blowing sound, depending upon the escape of a certain amount of air into the pharyngeal vault, is heard with the open ear. With partial or complete occlusion of the Eustachian canal, or when its pharyngeal orifice is filled with secretion, this sound becomes louder, and, if the trumpet-shaped orifice of the tube contains viscid mucus, is of a hoarse, rasping quality as the air bubbles through it. While these sounds may be heard even when the instrument is correctly placed if the parts are swollen and inflamed, still they most frequently indicate that the catheter has been improperly manipulated, and that the tip lies in Rosenmüller's fossa, behind the tubal orifice. Occasionally the catheter is pressed so forcibly against the lateral wall of the pharynx as to completely occlude the lumen, and no air can be forced through the instrument upon attempting to perform inflation. A forcible effort at inflation may partially overcome the resistance, giving rise to a harsh, rasping sound as the current passes from the instrument and overcomes the elasticity of the mucous membrane which has occluded the opening. Sometimes, instead of lying exactly in the pharyngeal orifice, the instrument impinges upon the posterior lip of the tube. The pharyngeal bruit will predominate if this is the case, and will be of a particularly discordant, vibratory character, the cartilaginous plate forming the posterior wall of the tube being thrown into irregular vibrations each time the bag is emptied.

While the preceding description of these sounds may seem complicated, their recognition is simple after a little practice, and it is easy to recognize any undue prominence of the tubal, tympanic, or pharyngeal factors of the bruit. The information gained by close attention to this method of examination will amply repay one for the labor expended in perfecting himself in it.

But one method of introducing the catheter has been given as yet, for the reason that it has seemed better to take this one as the standard, and to describe the variations in technique which may be resorted to when this first method, for any reason, is not successful. It is advisable for the beginner to adhere closely to one method of catheterization rather than to resort to several as soon as difficulties arise, it being more easy to become expert in the manipulation by the constant use of one method.

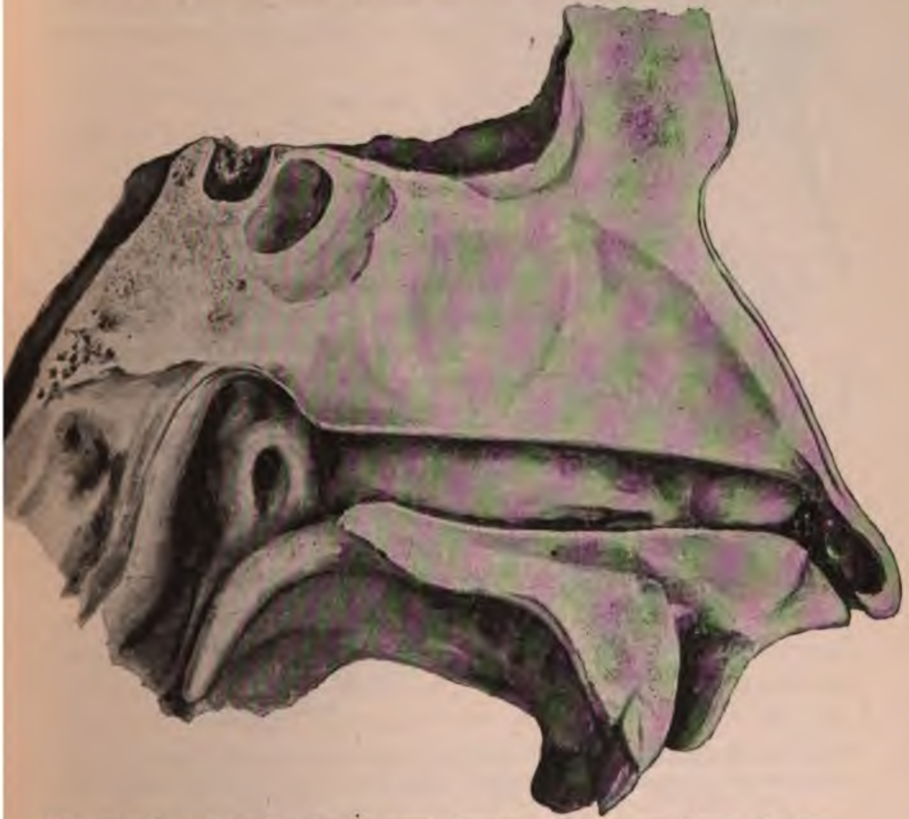


FIG. 49.—Vertical section through nasal chambers and pharyngeal vault of adult. The lower portion of the septum, opposite the inferior turbinated body and the inferior meatus, has been removed, exposing the course followed by the catheter. The Eustachian orifice is well marked. (Author's specimen.)

Loewenberg * modifies the technique in the following manner: When the pharyngeal extremity of the catheter is felt to impinge upon the posterior wall of the naso-pharynx the in-

---

* Arch. für Ohrenheilk., vol. ii, p. 12.

strument is rotated upon its long axis so that the guide ring shall be directed toward the opposite ear; the catheter is then drawn forward until its concavity is felt to engage the posterior margin of the nasal septum; it is then rotated downward through an angle of one hundred and eighty degrees, until the guide points toward the ear to be inflated, while at the same time the catheter is carried toward this side.

According to the writer quoted, when rotation has been completed, the beak of the instrument will be found to lie in the mouth of the Eustachian channel. The prolonged manipulation is rather prone, in my experience, to cause a contraction of the muscles of the soft palate, and therefore constitutes a source of discomfort to the patient. The variations in the exact position of the tubal orifice and in the transverse diameter of the naso-pharynx, detract much from the special value of this method. The same technique had previously been advocated by Frank.* Boyer † prefers to rotate the instrument

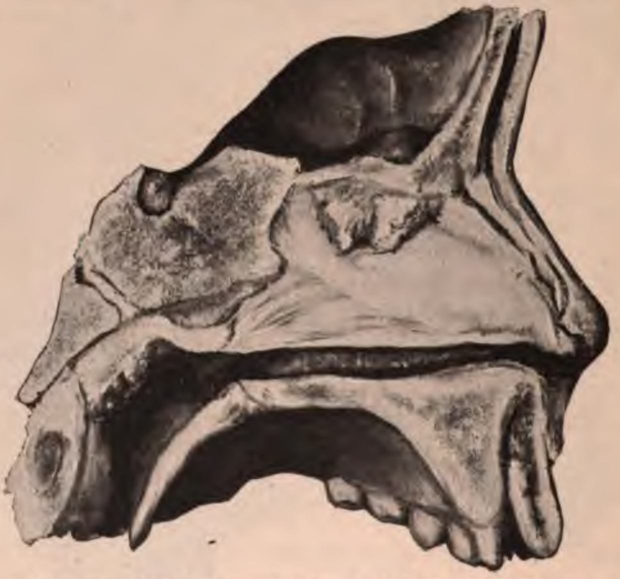


FIG. 50.—A section made in the same manner as that shown in Fig. 49, showing the conformation of the parts in a child of five years. The pharyngeal vault is filled with adenoid vegetations, and the tubal orifice is less marked and lies farther forward than in the adult. (Author's specimen.)

---

* Lehrb. der Ohren., 1845, p. 101.

† Annal. des mal. de l'oreille, 1877, vol. iii, p. 69.

upon its long axis, as soon as the tip passes the choanæ, as recognized by the diminished sensation of resistance to the entrance of the instrument, until its extremity points to the affected side. Its exact insertion into the tubal orifice is effected by pressing the beak outward toward the lateral pharyngeal wall. This method is occasionally of service when the parts are irritable, and the operator knows, from previous experience, the exact location of the tubal opening.

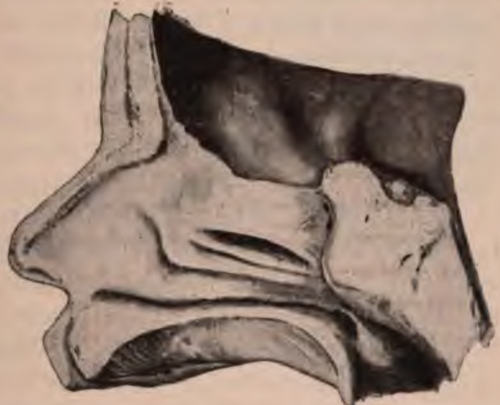


FIG. 51.—A section through the nasal passages and naso-pharynx in an infant, showing the turbinated bodies and tubal orifice. The lips of the tube are poorly defined. A similar condition is frequently met with in advanced life. (Author's specimen.)

Triquet * follows almost the same plan, but rotates the catheter before it leaves the inferior meatus, so that it may be arrested by the tubal prominence as it is pushed farther backward.

Wolff † and Gruber ‡ advise that after the instrument, with the pharyngeal extremity directed downward, has been passed through the inferior meatus until the pharyngeal wall is reached, it shall be drawn forward until it is arrested by the soft palate; it is then advanced slightly toward the posterior pharyngeal wall, after which the angular portion is rotated toward the ear to be inflated, causing the extremity to enter the tubal mouth.

Kramer # suggests that use be made of the reflex contraction of the soft palate, which is excited by the presence of the catheter, to cause the instrument to assume its correct position in the tubal mouth. Having carried the catheter backward to the posterior wall of the naso-pharynx, it is drawn forward over the prominent posterior lip until it impinges upon the soft palate. This manipulation is followed by a contraction

---

* Traité pratique des mal. de l'oreille, 1857.

† Lencke's Handb. der Ohrenheilk., vol. iii, p. 358.

‡ Lehrb. der Ohrenheilk., Vienna, 1888, p. 203.

Ohrenkrankheit., 1836, p. 248.

of the palatal muscles, which forces the instrument upward. At this instant it is quickly rotated toward the affected side, the contraction of the palate crowding it into the tubal orifice.

It will be seen that in all of these methods, with the exception of Frank's, the technique of introduction is but slightly modified from that first described, and that the facility with which the operation can be performed will depend greatly upon the ability of the operator to recognize the various structures which the pharyngeal extremity impinges upon, after the instrument has entered the naso pharynx.

Obstacles to Catheterization.—Certain difficulties depending upon anatomical characteristics peculiar to any given case may be encountered in attempting to perform catheterization. The most frequent obstacle is a considerable deformity of the septum narium, causing a partial occlusion of the inferior meatus. Since the introduction of cocaine, catheterization has become much more simple, as the exsanguination of the turbinated tissues increases the dimensions of the cavity materially, while at the same time, on account of its anæsthetic properties, prolonged manipulation is possible. Before attempting to introduce the Eustachian catheter, it is always wise to make a careful anterior rhinoscopic examination, to determine the presence and nature of any obstruction. If a considerable obstructive lesion exists, the catheter may be introduced under direct inspection, the parts being illuminated by reflected light, and the eye directing the various movements of the instrument until it has entered the naso-pharynx. A ridge upon the septum, which extends horizontally toward the outer wall of the cavity, is perhaps the most perplexing condition found. The curve of the catheter must be such that it may traverse the inferior meatus beneath the obstructing ridge; herein lies the advantage of a pure silver catheter, since it is a simple matter to change the curve of the instrument to suit the particular condition encountered in any case. It is not always possible to introduce the instrument with the curved extremity pointing downward, when a prominent ridge or excrescence presents anteriorly, and it is often advisable in such cases to turn the tip of the catheter to one or the other side, effecting its introduction into the cavity in the oblique diameter rather than in the vertical. Again, when there is a prominent ridge at the very entrance of the vestibule, and the passage beyond is obstructed as well, it may be necessary to enter the nasal cavity with the catheter so held that the concavity is directed upward, the convexity applying itself to the depression just within the vestibule. In such a case, as soon as the naso-pharyngeal space is entered, the instrument should be rotated until it has assumed the proper position. This rotation should be made toward the unaffected side to avoid touching the lateral pharyngeal wall.

It sometimes happens that the conformation of the parts will not allow the instrument to enter the inferior meatus, although the middle meatus may be capacious. In such an event, if the catheter is so bent as to increase the length of the angular portion, it is a simple matter to pass it through the middle meatus, above the obstruction, until the pharyngeal wall is encountered; after it has passed into the naso-pharynx the extremity of the instrument held in the fingers is elevated—a manipulation which will allow the long, angular part to engage in the tubal mouth upon rotation, although the horizontal portion of the instrument lies at a higher level than the entrance of the tube. Naturally, the greatest delicacy must be exercised in conducting this procedure, as from the increased length of the angular portion it will be easy to wound the delicate tissues of the naso-pharynx in rotating the instrument upon its long axis at the moment when the extremity is carried into the mouth of the tube.

When one nasal passage is blocked so that the introduction of a catheter is impossible, it may be carried through the passage of the opposite side, as advised by Deleau.* The curved portion of the catheter must be considerably longer than usual, and if the vault of the pharynx is unusually wide the procedure is not satisfactory, as a rule. The technique consists of carrying the instrument through the nasal passage of the opposite side, the free extremity resting upon and gliding along the floor of the inferior meatus. When the posterior pharyngeal wall is encountered the instrument is rotated so that the pharyngeal extremity points toward the ear to be inflated. The catheter is made to enter the fossa of Rosenmüller by carrying the extremity of the instrument held between the fingers away from the septum, until further motion is prevented by the lateral pharyngeal wall. The instrument is now drawn outward for about one fourth of an inch, or until the prominent posterior lip of the tube is felt; it is made to glide over this by drawing it outward, while at the same time the outer extremity of the instrument is elevated so as to allow the angular portion to pass over the posterior lip of the tube close to its lower margin; the outer extremity of the instrument is then carried away from the side to be inflated—a manipulation which forces the pharyngeal end into the mouth of the Eustachian tube. This method of catheterization is unsatisfactory to the surgeon and painful to the patient, the length of the angular portion of the catheter making delicate manipulation an impossibility, while at the same time it projects so far downward that when the instrument is rotated, considerable irritation of the pharyngeal mucous membrane is produced. Noyes has devised a catheter (Fig. 52), the pharyngeal extremity of which is bent at first downward and then upward and outward, which enables catheterization to be performed through the opposite nostril somewhat more easily than when the ordinary Eustachian catheter is employed. If the operator uses the silver catheters, which, on account of their malleability, can be made to assume any desired curve, it is comparatively simple to convert an ordinary Eustachian catheter into one possessing a double curve by bending it between the fingers. By a careful inspection of the nasal passage through which the instrument is to be introduced, the operator will be able in

---

* Rev. méd., 1827.

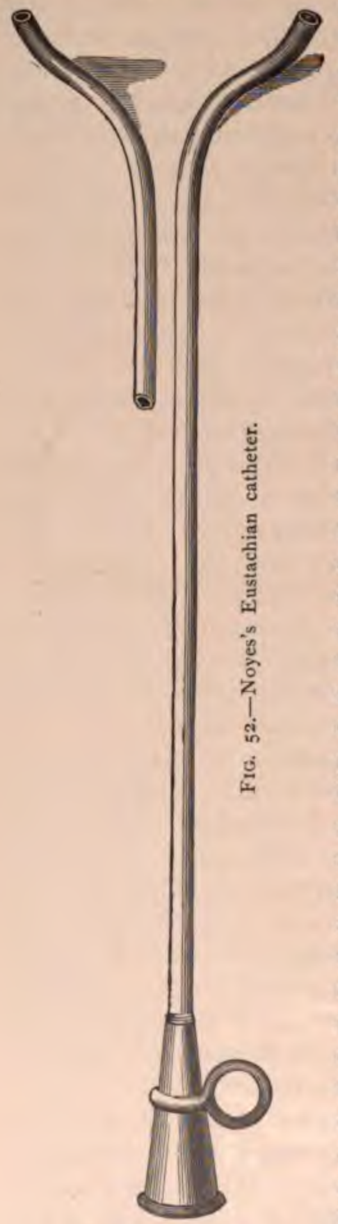


FIG. 52.—Noyes's Eustachian catheter.

many instances so to mold the instrument as to render its introduction comparatively simple. By giving it the double curve already described we overcome the necessity of the increased length of the angular portion, which is always a source of discomfort to the patient.

One other method of catheterization remains to be described—viz., the introduction of the instrument through the mouth. This was first advised by Kessel * in cases in which the nasal passages were occluded. Pomeroy † in this country has been an ardent advocate of the procedure, and frequently employs it in preference to the usual method. He has devised a special instrument which is shown in Fig. 53.

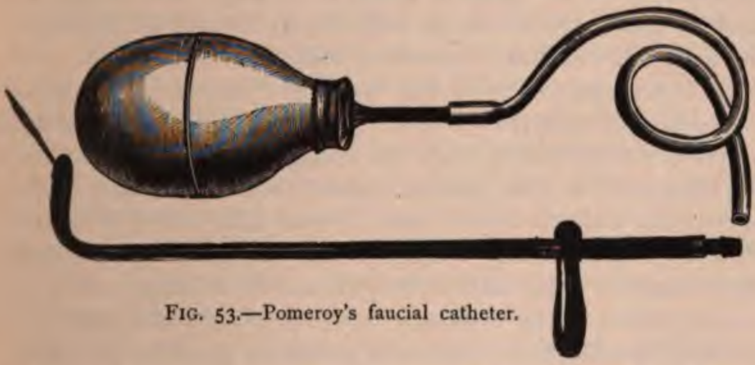


FIG. 53.—Pomeroy's faucial catheter.

As I have had no personal experience with this method, I can give no opinion as to its utility. It is simply mentioned here as an available procedure, which may be employed at the discretion of the surgeon.

Deformities of the nasal passages, however, are not the only obstacles to catheterization. The exact location, form, and prominence of the pharyngeal extremity of the Eustachian tube varies not only in different cases, but also in the same individual at different times, according to the degree of congestion of the surrounding parts. The position and shape of the pharyngeal orifices may also be asymmetrical in the same individual. It frequently happens that the tubal lips are so poorly developed that their recognition by the sense of touch is almost impossible; on the other hand, they may be so abnormally developed that difficulty is experienced either in

---

* Archiv für Ohrenheilkunde, vol. xi, p. 218.

† Diseases of the Ear, New York, 1883, p. 28.

drawing the instrument forward over the posterior lip or, in some cases, even in passing it backward sufficiently to permit rotation. The pharyngeal vault is occasionally so wide that upon rotation the catheter reaches the lateral wall with difficulty. In such an event the straight portion of the catheter must be crowded so far toward the nasal septum as to cause considerable discomfort by pressure upon the intranasal structures, or the angular portion must be so long as to render the passage of the instrument through the nasal chamber difficult, and to render rotation almost impossible.

Again, the mouth of the tube may be located high up in the vault of the pharynx, and its shape may be such that the catheter must be rotated through an angle of at least 135°, or even more, before its tip rests in the mouth of the tube so as to permit of a fully successful inflation.

It is only necessary to bear in mind these various obstacles in order successfully to overcome them. Delicate manipulation will enable the operator to recognize the posterior lip of the tube after a little practice, even if it projects only slightly above the smooth lateral wall of the pharynx. Where the pharynx is abnormally wide, the curved portion of the instrument must be increased in length, and if rotation can not be accomplished in the ordinary way, the outer extremity of the catheter should be elevated as much as possible to effect a corresponding depression of the tip of the instrument, to enable it to pass below the tube, after which rotation can be performed easily. The timidity of the patient when catheterization is performed for the first time is another difficulty to be mentioned. This is especially the case if the mucous membrane of the naso-pharynx is irritable, in which event the muscles frequently contract the moment the instrument enters the cavity, and hold it so firmly in their grasp as to prevent its rotation into the mouth of the tube. This spasm of the palatal muscles causes the instrument to be so firmly grasped that its mere presence in the pharyngeal vault is painful. The slightest motion augments this pain and increases the muscular rigidity, so that it is quite as impossible for the operator to withdraw the catheter, as to proceed with the operation. Occasionally no inconvenience is experienced until rotation is attempted, when contact with the lateral wall of the pharynx excites the act of deglutition, and the sudden muscular contraction displaces the catheter and crowds it against the lateral wall of the pharyngeal space with considerable force. If the patient is directed, at the outset, to keep the mouth closed and respire regularly and quietly through the nostrils, there is much less danger of such reflex muscular contraction. If as the instrument enters the pharynx the patient shows an inclination to cough or to swallow, it is well to divert his attention by requesting him to close the lips and to breathe quickly and deeply through the nose. Even an attempt to do this will cause a momentary relaxation of the palatal muscles, and during the interval the introduction of the instrument can usually be effected. If reflex contraction of the muscles takes place in spite of all precautions, the instrument should be held perfectly still during the period of muscular spasm, as any attempt to withdraw or advance it adds seriously to the discomfort. Relaxation is sure to take place in a few seconds, and then the instrument can be carried to the proper position or removed, as seems desirable. Reflex cough occurring during the act of catheterization should be managed in the same manner. It is to be remembered that when the instrument is once in position, coughing, swallowing, or any other muscular movement does not interfere with it in the slightest, and when correctly placed its presence causes no discomfort.

It occasionally happens that, by mistake, the catheter is passed through the middle meatus instead of through the inferior channel. This need never occur accidentally if the head of the patient is maintained in a slightly flexed position. The almost irresistible impulse on the part of the patient to extend the neck causes the instrument to enter the middle meatus, even when it is passed horizontally inward. With the head bent slightly forward this can not occur. It must be borne in mind, in conclusion, after discussing the principal difficulties met with, and suggesting measures to avoid and overcome them, that the utmost gentleness must be exercised throughout the entire performance of the operation. The catheter should be allowed to find its way into the pharyngeal vault, and should be allowed to rotate one way or the other, as may seem necessary to avoid obstacles. It is only necessary for the operator to prevent its passage into the middle meatus. When the nasal channel is extremely irregular complete rotation about the long axis of the catheter frequently occurs during its course from the anterior to the posterior nasal opening. The slightest pressure is sufficient to advance it when properly directed, and no force should be used. Any hæmorrhage following catheterization is a reproach to the operator in every instance. It is true that an occasional abrasion of the nasal mucous membrane occurs at the hands of the most careful manipulator, but one should always feel that there is no excuse for the accident. It is a procedure in which gentleness and care should be combined with skill, and he who can not exercise these is incompetent to carry out the operation.

As to the use of cocaine for the production of local anæsthesia, it may be said that since the drug has come into common use, it is frequently employed for this purpose in catheterization. It certainly diminishes the discomfort attending the passage of the instrument through the nose, if the channel is irregular or narrow, and at the same time by shrinking the turbinated bodies increases the width of the nasal passage. It may be stated, however, that under normal conditions the inferior meatus is not sensitive to the presence of the instrument, and observations upon quite a large number of cases in reference to this point have convinced me that quite as much discomfort follows catheterization when local anæsthesia is employed, as when no cocaine is used. In many, the disagreeable sensation as of a foreign body in the pharynx, due to the drug, constitutes a much greater source of discomfort than that produced by the introduction of the instrument without local anæsthesia. No objections can be raised to the use of cocaine, however, and it is always wise to employ it in cases where the nasal passages are so tortuous as to necessitate rather prolonged manipulation. Moreover, the knowledge on the part of the patient that the drug has been used, certainly produces a profound mental impression, and relieves any anxiety as to the discomfort to be endured. The drug is best applied in a ten-per-cent solution, a small quantity being first sprayed into the nostril by means of an ordinary hand-ball atomizer. A few moments suffice to secure contraction of the turbinated tissues, during which time it is well to have the head inclined a little forward to prevent the passage of the solution into the pharyngeal vault. Next, a cotton holder, mounted with a small pledget of cotton moistened with the same solution, is to be passed through the inferior meatus, along the course to be traversed by the catheter, the manipulation being conducted under illumination from the head mirror. The applicator should not be carried beyond the choanæ if the unpleasant sensation of fullness in the pharynx which the drug causes is to be avoided. If there is reason to suspect that the naso-pharynx will be unusually irritable—a condition with which we frequently meet in cases of acute naso-pharyngitis—it is well to anæsthetize the mouth of the tube as well as the nasal passages. This is done by means of the cotton-tipped probe, the extremity of which is bent to correspond to the curve of the catheter. Under inspection, this instrument is to be passed through the nasal passage exactly as the catheter would be introduced, care being taken that the patient's mouth is closed, and quiet nasal respiration continued. The same manipulation employed in the introduction of the catheter enables the cotton-tipped probe to be inserted into the orifice of the Eustachian canal, care being taken that the pledget is not saturated with the solution, as otherwise a considerable quantity will be spread over the pharyngeal mucosa. When the orifice of the tube is reached, the applicator is allowed to remain in this position for a few seconds to ablate completely the sensitiveness of the mucous membrane; catheterization is now easily performed. In addition to securing local anæsthesia by the introduction of the cotton pledget in the manner already described, the operator accomplishes another purpose, since he cleanses the orifice of the tube and removes any inspissated secretion which may be present, and which would be an obstruction to successful inflation.

The Dangers of Catheterization.—From the fact that three deaths have followed the procedure it is looked upon by those unacquainted with the operation with a certain degree of perturbation. Inflation in these fatal cases was performed by means of compressed air, the degree of condensation being extreme. This method, as already stated, is seldom used at present, and it is safe to say that no damage can be done with any form of hand apparatus devised for the purpose of inflating the middle ear through a catheter.

Death in these cases was probably caused by suffocation from submucous emphysema, due to the air having been forced beneath the mucous membrane, the surface of which had been abraded by the extremity of the catheter. The occurrence of emphysema need not of necessity be followed by serious results, although the symptoms which supervene are always alarming to the patient, and may be disturbing to the operator. When this accident occurs, the air may either be absorbed spontaneously, or, if the emphysematous area is extensive, the condition may demand relief by surgical interference. Puncture of the tissues suffices to evacuate the air and to relieve the symptoms at once. It should be stated, however, that if even ordinary care is used in catheterization, emphysema will never be produced, and one who can not introduce the Eustachian catheter without abrading the mucous membrane of the naso-pharynx had better not introduce it at all. The only possible excuse for the accident would be catheterization immediately after the introduction of the Eustachian bougie; therefore it should be the invariable rule never to inflate the middle ear at once after the passage of such an instrument.

Occasionally, inflation of the tympanum, either by Politzer's method or by the introduction of the catheter, is followed by immediate dizziness, due to the sudden disturbance of labyrinthine pressure. No judgment can be formed beforehand concerning the likelihood of this occurrence. It is always well when the procedure is conducted for the first time to begin the inflation very gently, allowing but little air to enter the tympanum at first, and gradually increasing the strength of the current if unpleasant symptoms do not supervene. The dizziness, which is sometimes so severe that the patient falls from the chair and becomes unconscious for a moment, is terrifying, but not dangerous. Where the membrana tympani is very thin, either as a result of a previous inflammatory process with the subsequent formation of cicatricial tissue, or from atrophic changes, a forcible inflation may rupture it. It follows, therefore, that the use of Politzer's method or catheterization should be preceded by an inspection of the drum membrane.

The Comparative Value of Politzerization and Catheterization.—Having now considered these two methods of forcing a current of air through the Eustachian tubes and into the middle ear, a few words as to their relative value may not be out of place. As a means of diagnosis, inflation by the catheter is always preferable, as it enables the surgeon to estimate the force necessary to propel the air through the canal, to observe the effect upon the auscultation sounds resulting from variations in the strength of the air current, and to repeat the experiment as often as he may desire. Moreover, success or failure in accomplishing the end lies entirely in the hands of the operator if the catheter is employed, while when the air bag is used by Politzer's method, the success or failure lies quite as much with the patient as with the surgeon, as it depends upon his ability completely to close the naso-pharyngeal space by elevation of the soft palate.

In the adult the auscultatory sounds are so weak when Politzer's method is used that very little information is gained by using the diagnosis tube. In children under twelve years of age, however, the Eustachian canal is quite short, and its calibre comparatively large in proportion to its length. At this age catheterization is somewhat difficult, while the air bag fitted with a proper nose piece usually opens the tube perfectly, and the sounds produced within the tympanum are sufficiently strong to be perceived through the diagnosis tube.

As a diagnostic measure, then, Politzer's method should be used in young children and in those cases where the nasal passages are obstructed to such an extent that the introduction of the catheter is well-nigh impossible.

As a therapeutic measure the catheter is decidedly superior to Politzer's method, allowing as it does the inflation of either ear without disturbing the organ of the opposite side and permitting the application of various medicated vapors directly to the membrane of the tube and tympanum, without bringing them in contact with the mucous membrane of the nasal cavity.

When Politzeration must be employed from necessity, the action of the air may be confined to one ear by the insertion of the finger into the opposite meatus, thus compressing the air in the canal and rendering any appreciable outward displacement of the membrana tympani impossible. The advantage of catheterization, mentioned in comparing the two methods for diagnostic purposes, holds good in this connection as well—that catheter inflation allows an exact graduation of the force employed, the bulb being pressed more or less strongly as indicated by the freedom with which the air passes into the middle ear. The objection so frequently raised against catheterization—that the instrument inflicts a certain amount of traumatism on the structures against which it impinges—need scarcely be mentioned. It is quite true that harsh catheterization always does more damage than good, but harsh catheterization is never to be employed, for, as before stated, the exercise of care will enable even the beginner to introduce the instrument without inflicting any injury, even if he is not successful in directing the instrument into the pharyngeal orifice of the tube.

The Examination of the Nose, Naso-pharynx, and Pharynx.—Under no circumstances should the surgeon consider his physical examination complete until he has inspected the regions above mentioned which, by their anatomical position, exert a powerful influence upon the ear both in health and in disease.

As the mucous membrane lining the nasal cavities and the naso-pharyngeal space is continuous with that lining the middle ear, an intimate relation exists between the nerve and blood supply of the two regions, rendering the ear particularly susceptible to reflex disturbances depending upon some intranasal exciting cause, as well as to circulatory changes from alterations in the blood and lymph current within either the nasal chambers or the pharyngeal vault. After a satisfactory otoscopic examination has been made, the next step should be to inspect the oral cavity by means of reflected light, observing the condition of the mucous membrane in the mouth; the presence of carious teeth; the appearance of the posterior pharyngeal wall, whether it is dry or moist; whether it presents the smooth, velvety appearance of a normal mucous membrane, or is studded here and there with irregular elevations, indicative of the presence of small lymph nodules just beneath its superficial epithelial layer In this connection attention need scarcely be called to the importance of observing those two large masses of lymphoid tissue situated between the pillars of the fauces—that is, the faucial tonsils. Under normal conditions the tonsils do not project beyond the faucial pillars, and special effort must be made to see them in a condition of perfect health, by crowding the anterior faucial pillar against the lateral wall of the pharynx, or turning the head of the patient first to one side and then to the other, to permit the observer to look obliquely across the cavity of the mouth, in order that they may be brought into view. Any projection of these bodies beyond the pillars of the fauces constitutes an abnormity.

The vault of the pharynx next demands investigation. In very young children posterior rhinoscopy is impossible, and here resort may be had to digital examination. In this procedure the mouth of the patient should be held open by a cork inserted far back between the jaws, or better by the use of a mouth gag. The index finger, with the palmar surface downward, should then be introduced into the opposite angle of the mouth. It should then be passed rapidly along the dorsum of the tongue until it meets the posterior pharyngeal wall, when, by quickly turning the palmar surface upward, it is passed behind the soft palate into the naso-pharyngeal space, the palate yielding readily to gentle but firm traction. By drawing the finger forward the nasal septum should now be recognized and followed upward until the roof of the cavity is felt. The sensation imparted to the examining digit should be observed: whether the membrane is soft and spongy, indicative of the presence of an abnormal amount of lymphatic tissue, or whether it differs but little from the sensation imparted by the mucous membrane covering the posterior wall of the oro-pharynx. These facts having been determined, the tip of the finger is turned first to one side and then to the other, and easily appreciates the Eustachian prominences, after which it is withdrawn; by sweeping along the posterior wall of the naso-pharynx in making its exit, the presence of any abnormal amount of lymphoid tissue in this location is determined.

The presence of adenoid tissue in the vault of the pharynx affects the ear in two ways. If the mass is large, by direct pressure upon the Eustachian orifice the supply of air in the tympanic cavity may be disturbed. This fact will be appreciated by reference to Fig. 50. It is evident that the enlarged pharyngeal tonsil, seen in this drawing, lies so closely to the posterior lip of the tube that any increase in volume would interfere with the patency of the canal. Any slight increase in volume of the mass will close the lumen of the tube, after which the intratympanic air is gradually absorbed by the blood which circulates through vessels in the walls of the cavity. With each act of swallowing, at which time the tube opens momentarily, the air is aspirated into the naso-pharynx, the tube closing so quickly that the passage of air into the tympanum does not take place. In this manner a passive congestion of the mucous membrane of the middle ear is produced, a condition which constitutes practically the first stage of an inflammation, and, if long continued, results in permanent tissue changes.

I am inclined to think the more important manner in which adenoid growths, especially those of moderate size, affect the organ of hearing is by the obstruction to the venous return current from the tympanum and labyrinth. It must not be forgotten that the pharyngeal tonsil constitutes nothing more than a lymphatic gland, and, in virtue of its presence, may exert sufficient pressure to partially obstruct the venous flow from the tympanic cavity. Any condition which affects, for a considerable period, the circulation within the middle ear, will also cause a disturbance of the labyrinthine circulation from an alteration in the tension of the fluid contained. Such changes in the labyrinth, however slight, render this portion of the economy particularly susceptible to inflammation, either as the result of infection or of mechanical irritation, the most fruitful source of the latter being the crowding inward of the ossicular chain by atmospheric pressure, when the tension of the air within the tympanum is reduced. Evidence is not wanting, from a clinical point of view, that even in very early life the labyrinth may be affected by the presence of growths of this kind. We not uncommonly find instances of tubal catarrh in children in whom these growths are present; instead of presenting, upon functional examination, the reactions characteristic of the affection, these cases show a diminution of bone conduction, and sometimes a hyperæsthetic condition of the auditory nerve, both of which phenomena indicate an irritative lesion of the labyrinth. In very young children it is of the utmost importance to determine the presence or absence of a growth of this kind, even where the history seems to show that the child is entirely deaf, for, as articulate speech is acquired simply by imitation, an impairment of audition which in an adult or in a child of a few years of age would be practically insignificant, in a child so young that the function of audition has never been exercised, may give rise to all the symptoms usually found in a deaf-mute.

The oro-pharynx and the pharyngeal vault having been examined in the manner stated, attention should next be directed to the anterior nares. The nasal cavity should be inspected by anterior rhinoscopy, the tip of the nose being tilted up by means of the thumb of the left hand, the fingers of the hand resting upon the forehead for support, while the nasal orifice is dilated gently with a self-retaining speculum (Fig. 54). The patient's head should be flexed slightly forward, in such a position that the floor of the nasal cavity will be nearly horizontal. When the light from the head mirror is directed into the cavity the observer inspects first the inferior meatus, and remarks if any deformity of the septum is present, determining its extent, nature, and location, as well as the size, shape, and color, of the inferior turbinated body; whether it is turgescent and occludes the inferior meatus to a considerable extent, or whether its mucous membrane is of the normal light rosy tint, and its rich venous plexuses are not abnormally engorged. Under normal conditions, where no deformity of the septum exists and the turbinated tissue is not swollen, the observer can readily see the posterior wall of the naso-pharynx by anterior rhinoscopy, and, in fact, the author has found this one of the most simple methods of determining the presence of hypertrophied lymphatic tissue in this region. This portion of the examination is rendered more complete if a weak solution of cocaine is sprayed into the anterior nares, before an attempt is made to inspect the naso-pharynx in this manner. The anæthesia this produces renders it the simplest possible procedure to add to our information by touching the various parts under inspection with a cotton-tipped probe passed through the anterior nares. The inspection of the lower meatus and naso-pharynx having been completed, the head is now tilted backward, and the observer directs his attention to the upper part of the nasal chamber. In the anterior portion the eye recognizes readily the tip of the middle turbinated body, which, normally, is of a somewhat lighter color than the lower turbinate and less freely supplied with venous channels, for which reason its mucous membrane seems to be more closely applied to the bony framework, the entire structure projecting less into the lumen of the passage than does the inferior turbinate. Any deviation from this normal appearance should be carefully noted as constituting a source of obstruction to nasal respiration. It should be remembered that the furrow or hiatus beneath the middle tur-

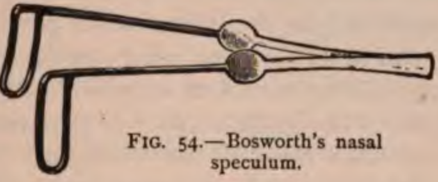


FIG. 54.—Bosworth's nasal speculum.

binated body contains the opening of the frontal, anterior ethmoidal, and maxillary sinuses; consequently it should be inspected with special care for the presence of a purulent discharge which, when lying here, is almost pathognomonic of an inflammation of one of these accessory cavities. This also is the region from which nasal polypi most frequently take their origin, and the possible presence of these growths must always be borne in mind during this stage of the examination.

We have spoken only of the hypertrophic condition, since this is the lesion usually presented in cases which come under the observation of the otologist. It must be remembered, however, that precisely the opposite state of affairs may constitute a morbid condition—that is, instead of an hypertrophy of the lining membrane, this may be abnormally thin, the turbinated bodies lying close to the outer wall of the passage and projecting but little into the lumen. When the condition is extremely well marked, they are discernible with some difficulty. Under these circumstances the mucous membrane, instead of being moist, has a dry, glazed appearance, while in the sulci between or beneath the turbinated bodies, large greenish-yellow crusts are seen. These result from the inspissation of the nasal secretion, which, owing to the atrophy of the lining membrane, is wanting in fluidity. The naso-pharynx also, instead of showing the presence of lymphatic tissue, may appear glazed, and may be covered, to a greater or less extent, with a thick, tough mucus, usually in the form of a scale or shell, which spreads irregularly in all directions from the median line. This naso-pharyngeal condition is seldom found before the age of twenty, and is usually due to retrograde changes in the lymphoid tissue of the region, which in early life had undoubtedly been moderately but not excessively hypertrophied. Instead of disappearing completely after the age of puberty, as is often the case, interference with this retrograde process occurred for some reason, with the result that the fibrous elements of the pharyngeal tonsil persisted and increased in density, while the cellular elements disappeared. This local condition constitutes the lesion in the cases of so-called naso-pharyngeal catarrh, or chronic naso-pharyngitis. The appearance described can be recognized both by the anterior rhinoscopic examination, and by posterior rhinoscopy as well.

By posterior rhinoscopy we are enabled to obtain a view of those structures which are hidden from direct inspection by the curtain of the soft palate. This is accomplished by means of a mirror introduced into the mouth, with the reflecting surface directed upward, so that the image of the region in question is reflected in the mirror. In order to conduct this examination the patient is seated facing the surgeon, the arrangement of the light and the relative positions of the patient and operator being the same as those already given under the description of otoscopy. The head of the patient is inclined very slightly forward so that the hard palate lies in the horizontal plane. The surgeon now depresses the tongue with the tongue depressor held in the left hand, crowding the organ downward while, at the same time the instrument is rotated slightly by elevating the handle, the blade resting upon the incisor teeth, thus exerting slight forward traction. In this way efforts at retching on the part of the patient are avoided, as the base of the tongue, instead of being crowded into the throat, a circumstance which always results in exciting an effort of deglutition, is drawn forward out of the pharynx. The patient is directed to breathe quietly, and at an opportune moment, when the palatal muscles are relaxed and the velum hangs vertically downward, the rhino-

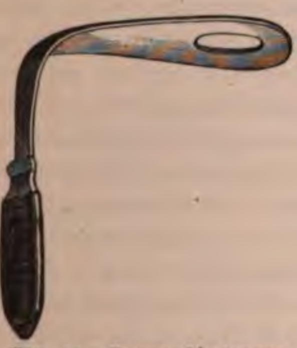


FIG. 55.—Bosworth's tongue depressor.

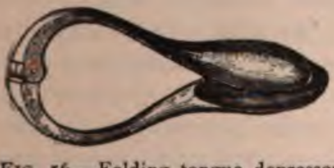


FIG. 56.—Folding tongue depressor.

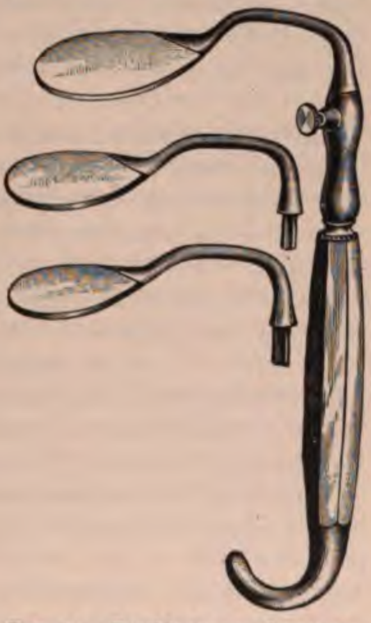


FIG. 57.—Türck's tongue depressor.

scopic mirror, previously slightly warmed over the lamp, is carried rapidly into the mouth and made to assume a position to the one side or the other of the uvula. The rays of light from the head mirror are directed upon the surface of the rhinoscopic mirror, which, as the inclination of its polished surface is about one hundred and thirty-five degrees, directs the rays impinging upon it into the retronasal space. At first the handle of the mirror should be carried slightly downward, which brings into view the posterior margin of the nasal septum; this should be followed upward until its narrow edge is seen gradually to broaden and finally to disappear in the upper wall of the naso-pharynx. In bringing the septum into view the presence of an hypertrophied posterior extremity of either lower turbinated body will easily be recognized by its marked encroachment upon the lumen of the corresponding posterior nasal orifice. In the same manner myxomatous growths, springing from the nasal cavities and extending into the naso-pharyngeal space, will also be easily discovered. Any increase in the lymphatic tissue near the pharyngeal roof will be at once evident, as its presence renders it impossible for the observer to follow the outline of the septum upward to where the divergent edges are lost in the pharyngeal roof the expanded portion of the septum being concealed by the hypertrophied lymphatic tissue. By gradually elevating the handle of the mirror the entire roof and a portion of the posterior wall of the naso-pharynx are brought into view, and by rotation of the mirror upon the long axis of the shank each lateral wall of the cavity is inspected and the prominent posterior lip of the Eustachian tube upon either side easily recognized. Behind this we observe the fossa of Rosenmüller, while in front is the orifice of the Eustachian tube, which varies in shape from a slitlike depression, to an opening with distinctly circular borders. (FIGS. 49–51.)

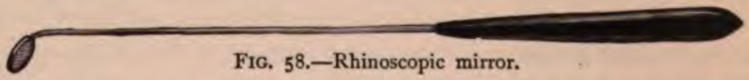


FIG. 58.—Rhinoscopic mirror.

PREPARATION OF INSTRUMENTS.

Before concluding the subject of the physical examination, a few words will not be out of place concerning the care of instruments used in conducting the examination. Too much stress can not be laid upon the necessity of absolute asepsis. All metal instruments should be sterilized by boiling in a two-per-cent sodium-bicarbonate solution before each examination. If rubber catheters are to be used, each patient should possess his own instrument, while if silver catheters are used they should be sterilized in the manner above described.

In cleansing the ear with a syringe, an aseptic solution or, better still, an antiseptic solution should always be employed. A solution of bichloride of mercury in the proportion of 1 to 5,000 is sufficiently antiseptic to prevent infection of the tympanic cavity if the drum membrane is accidentally perforated during the process of cleansing the canal. The tip of the ear syringe should be boiled immediately before use, or, if this is not convenient, the extremity should be covered by a small piece of soft-rubber tubing, which is renewed each time the syringe is used.

As the prolonged boiling of tempered instruments is injurious, these may be thoroughly cleansed with cotton and then dipped for a moment in the boiling soda solution, after which they are immersed in a five-per-cent solution of carbolic acid for several minutes.

It is scarcely necessary to call attention to the necessity of personal cleanliness on the part of the operator, and yet perhaps this is occasionally forgotten.

These measures have been recommended by many writers to avoid specific infection chiefly. In this country, where specific disease is not as common as upon the Continent, the above precautions are scarcely necessary for this purpose, but they are necessary to prevent purulent infection of the middle ear.

If the above precautions are adopted in every case, the extent to which operative procedures within the middle ear can be carried is surprising. In no region of the body, perhaps, is asepsis more important, and nowhere certainly has it been so utterly disregarded.

THE HISTORY.

A very important part in the intelligent investigation of any affection of the ear, involving a partial loss or perversion of its function is the general history of the patient, together with an exact account of the aural affection. It is scarcely necessary to give more than briefly the various subjects which should be investigated, before any decided opinion is given as to the nature of the affection or the probable course which it will pursue. These facts influence our opinion not only as to the favorable or unfavorable progress of the disease, but in no small degree enable us to determine the relative value of the various data with which our physical and functional examinations furnish us. The age of the patient, the occupation, and the habits of life should be first considered. The history of any previous illness must be investigated with great care, particularly concerning the occurrence in childhood of any of the exanthemata and other kindred diseases, and later in life of any of the continued fevers. A not unimportant factor is the presence of an hereditary taint—tuberculous, specific, gouty, or rheumatic—as well as the existence of chronic aural disease in any other members of the family. The habits of the patient regarding the use of opiates, stimulants, tobacco, indulgence in the luxuries of the table, or the fact of his having been called upon at any time to undergo severe mental strain or physical exertion, must also receive consideration. Special attention should also be paid as to whether, at any period of life, it has been necessary for him to take continuously large doses of the various drugs which are known to have a specific action on the auditory organs.

Next the *status præsens* should receive attention, particularly with reference to the digestive system, and here it must not be forgotten that the mouth is responsible for quite as much aural disturbance as the stomach, and inquiry should be made into the condition of the teeth. Any previous or present condition referable to the pelvic organs must also be inquired into. Much information may frequently be obtained by observing the general behavior of the subject in responding to the various questions, it being remembered that, in patients of a decidedly neurotic tendency, care must be observed in the interpretation of the apparent results obtained by a functional examination, the mere fact that they are under examination often disturbing them to such a degree that their answers are entirely untrustworthy.

When we come to the special history—that is, that part which bears directly upon the aural affection for which they seek advice—the length of time which this has existed must, if possible, be determined. It is of special importance to inquire into the condition of the ears in childhood, as not infrequently the patient may neglect to state the presence of aural symptoms in early life, conceiving that as these have apparently disappeared, they can have no bearing upon the present affection. The symptoms upon which the patient lays most stress generally, are impairment of hearing, tinnitus, discharge from the ear or pain in this location. Nausea, vertigo, general headache, etc., may have a very important bearing upon the malady, yet may be referred by the patient to entirely different causes and hence remain unmentioned unless he is questioned especially with reference to their previous existence. If the affection has been of long duration it is of the greatest importance to discover whether the progress has been uninterrupted, or whether under certain conditions it has been aggravated. In this connection the effect upon the ear of an acute inflammatory condition of the mucous membrane lining the nose or naso-pharynx, or of an aggravation of already existing catarrhal disturbances, is to be discovered, the intimate relation between the upper air tract and the organ of hearing rendering this of great moment. It may be taken as an almost invariable rule where the aural symptoms are intermittent in character, becoming more severe when the patient suffers from a cold in the head, that even if the pathological process is located in the middle ear, our treatment must be directed quite as much to the upper air passages as to the tympanum itself in order to obtain permanent benefit.

If the prominent symptom is an impairment of hearing or the presence of tinnitus we should discover under what conditions these are most troublesome—whether the patient hears better in a noisy or in a quiet place; whether the chief difficulty is that it is impossible to understand general conversation, or whether the impairment is so marked that even dialogue is impossible. Ascertaining the particular time during the day when the disturbance is most severe—whether in the morning, after a refreshing night's sleep, or at the end of the day, when tired both physically and mentally—may often aid us in forming our opinion. A word of caution should be added lest the physician may, by attaching too much importance to any one symptom, cause the patient to exaggerate it unduly. This is especially true in questioning him concerning his tinnitus. If distressing, he will complain of it without interrogation, but if this is not the case, only the most casual mention should be made regarding its presence.

CHAPTER IV.

FUNCTIONAL EXAMINATION.

As the aural surgeon is consulted most frequently on account of either impairment or perversion of function in the auditory apparatus, it would seem natural that he could arrive at the most perfect conception of the condition of this apparatus by testing the functional condition of the organ of hearing. It is strange, however, that while much attention has been paid to the observation of physical changes in the external and middle ear, which may be noted by ocular inspection, the functional examination has ordinarily been conducted in the most superficial manner.

By recalling the remarks made under Physiology, it will be remembered that the ear perceives not only the intensity of a sound, but also its pitch or quality; consequently a functional examination is complete only when it estimates both the qualitative and quantitative condition of audition.

I. Quantitative Tests.—In order to determine how much the quantitative function of the ear is impaired, it is only necessary to compare the distance at which any given sound is heard by the ear under examination, with the distance at which it is perceived by the normal ear.

For convenience, the hearing power is ordinarily expressed as a fraction, the denominator of which represents the distance in feet or inches at which the sound is normally heard, while the numerator designates the distance at which the sound is perceived in the affected ear under examination.

It should be borne in mind that as a single sound excites only one part of the perceptive apparatus, an ear which may be perfectly healthy otherwise may fail to perceive one sound on account of the destruction of this particular area in the cochlea, and in order to apply this test we must be certain that the perceptive mechanism will respond to the particular standard sound to be employed as a unit. In order that the results of various observers may be compared, use must also be made of a sound of a given quality and intensity; and herein lies one of the chief difficulties of comparing the results of tests made by different observers.

The sound most commonly employed in making a quantitative test, where the hearing is but moderately impaired, is the tick of the watch. While this may be fairly accurate in observations made by the same individual, it is manifestly impossible that any comparison of results reached by several examiners can be made. To obviate this difficulty, Politzer* devised the instrument shown in Fig. 59, which is supposed to produce a sound whose intensity and quality are always the same. This, perhaps, is the most universally used apparatus for conducting experiments of this kind. The chief objection is that as the sound produced by the instrument is heard by the normal ear at a distance of forty-five feet, its use is restricted to those cases in which the impairment of hearing is considerable. Moreover, it is not impossible that the particular portion of the perceptive apparatus which is responsive to this sound may be so affected that, while the function of the organ as a whole may improve, the distance at which this sound is perceived may remain unchanged.

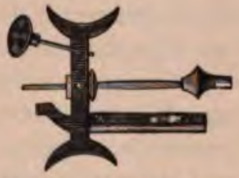


FIG. 59.—Politzer's acoumeter.

The ideal test in estimating impairments of audition is the human voice, since the patient desires especially that the power of audition for sounds thus produced shall be improved, and, moreover, because his own estimate of the progress of his disease is very largely based upon the ease or difficulty with which he is able to understand the human voice in ordinary conversation. Therefore, no matter what mechanical appliance may be used in estimating the power of audition, no system of examination is complete which fails to record the facility with which various vocal sounds are perceived. Since the conversational voice varies greatly both in pitch and intensity in different individuals, an exact comparison of the results obtained by using the conversational voice as a standard would be difficult. The whisper, however, is fairly constant in pitch and intensity, if care be taken that in every examination the whisper shall be as loud as possible, or what may be termed "a forced whisper." The examiner in carrying out this test should first fill the lungs by a forced inspiration, and then allow them to empty themselves by a normal expiratory effort, after which he should repeat in a whispering voice the particular word or words to be used as the test. I have taken pains to compare the data obtained by various observers by tests conducted in this manner, and find that the error of experiment is very small when the test is conducted carefully. It should be remembered that the patient soon becomes familiar with sentences used in these experiments, and when the same phrases are repeated frequently the results obtained are worthless. To avoid this result, Siebenmann * advises the use of numbers of two figures. In this way the patient can not become familiar with any given test sentence, as the same numbers are not repeated on successive examinations, or if repeated, their sequence is changed. We meet, however, with the difficulty that certain combinations of letters are more easily perceived than others, even when whispered with the same intensity—in other words, each vowel and consonant sound possesses an intensity peculiar to itself, the vowel sounds being more easily heard than consonant sounds. This characteristic of individual letters is denominated their logographic value, and the appended table, prepared by Blake, exhibits the relative intensity of the consonant sounds; the T sound being that of the greatest intensity, its value for purposes of comparison is denominated in the table as 100:

---

* Archiv für Ohrenheilkunde, vol. xii, p. 104.

T = 100
Z = 63
C = 62
P = 58
G = 56
B = 53
D = 45
S = 40
F = 35
K = 31
L = 21
N = 11
M = 9

If proper care is exercised in the selection of numbers of two figures, or if the numbers are selected at random, and the average results of ten experiments be taken as representing the quantitative value of the hearing in any particular case, a fairly accurate estimate of the condition may be obtained.

Instead of estimating the distance at which a sound of

---

* Archives of Otology, vol. xxii, p. 1.

known intensity is heard, another fairly accurate method consists in comparing the time during which a given musical note is perceived by the defective organ, with the perception time of the normal ear. The sounding body is set in vibration by a constant force, and the relation is expressed in the form of a fraction of which the normal perception time is the denominator and the perception time of the defective ear examined is the numerator. While not absolutely accurate from a mathematical point of view, the error is so slight that it may be practically disregarded, as proved by the experiments of Barth.* The only difficulty in testing in this manner is in obtaining a constant force for setting the tuning fork or any other convenient instrument in vibration. If each examiner determines his own standard experimentally, by estimating the time during which the fork is heard by the normal ear, it being set in vibration by a blow which habit has enabled him to make fairly constant, a comparison of such results will be perfectly possible and fairly accurate, it being only necessary that the rate of vibration, or the pitch, of the instrument be known, and that its note be pure—that is, free from overtones. The note usually employed is that of a tuning fork making five hundred and twelve V. D., which corresponds to the treble C of the musical scale, as it is more easy to construct an instrument of this pitch, free from overtones, than one of lower pitch.

It is scarcely necessary to mention the more complicated instruments which from time to time have been devised for determining quantitative audition. Their use has never become universal on account of their complex construction. The phonograph, supplied with a series of standard cylinders and capable of reproducing sounds which shall always be uniform both in pitch and intensity, is probably the most simple of these devices. The principle of the telephone has been used in constructing instruments for this purpose. Of these, probably that recommended by Urbantschitsch † is the best. The operation of this instrument and of other kindred devices depends upon gradually diminishing the intensity of a given sound by sliding the secondary coil of an induction apparatus, introduced into the circuit, over the primary coil.

---

* Archives of Otology, vol. xvii, p. 153.

† Lehrbuch der Ohrenheilkunde, Vienna, 1890, p. 39.

The sound is conveyed to the ear of the patient by means of an ordinary telephone.

In the instrument shown in Fig. 60 the sound employed is produced by the rapid interruption of the electric current by Neef's hammer. It is necessary that the vibrating hammer be completely inclosed, in order that its repeated blows may not be heard through the air in cases where the hearing is but slightly impaired, or by the opposite ear, where there is great impairment upon one side, the opposite organ being normal or nearly so.

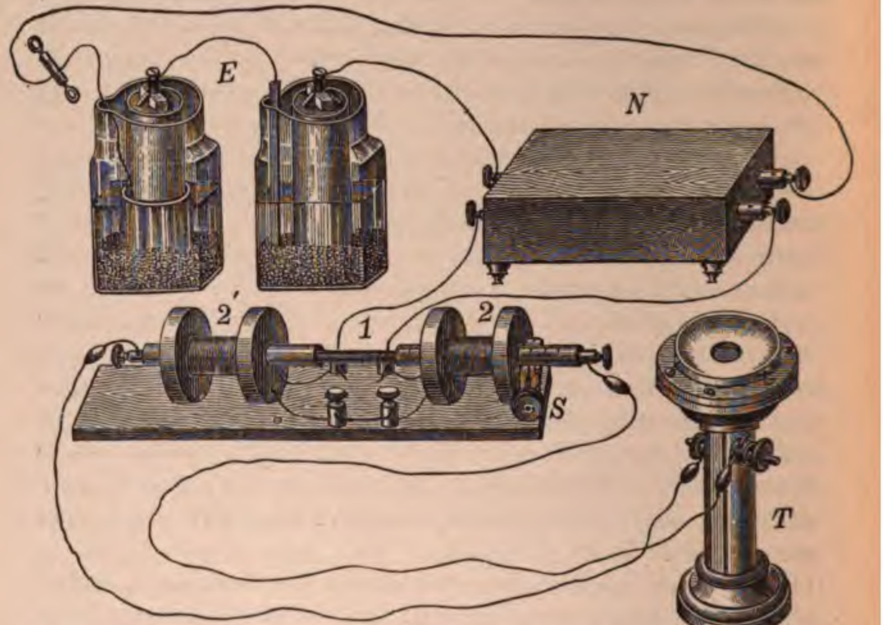


FIG. 60.—Urbantschitsch's electric acoumeter. *E*, Primary battery; *N*, Neef's hammer for interrupting the current automatically, and thus producing the sound to be employed in conducting the test; 2, 2', Induction coils of equal size, but wound in opposite directions; 1, Movable helix; *T*, Telephone; *S*, Screw for moving the helix. As the helix is withdrawn from one secondary coil, it enters the other, which is wound in the opposite direction, and the intensity of the sound heard through the receiver is thus increased or diminished at will. (Urbantschitsch.)

A somewhat similar instrument has been devised by Gradenigo,* in which the source of sound is a metal rod producing a pure musical note corresponding to C in the musical scale.

---

* Handbuch der Ohrenheilkunde von Schwartze, Leipzig, 1893, vol. ii, p. 383.

This certainly possesses advantages over the instrument just described, in which the quality of the sound must vary considerably.

The maximal phonometer was devised by Lucae* to measure the intensity of a vocal sound by observing to what extent the vibrating column of air displaced a diaphragm upon which it was made to impinge. The instrument is too complicated to be used universally.

Whatever method is adopted in making a quantitative test, certain precautions must be taken to avoid error in cases where a marked impairment of hearing exists in one ear, with only a very slight impairment in the function of the other. It is impossible to prevent the normal ear from perceiving sounds of great intensity, no matter how tightly the external auditory canal is closed, and as a preliminary step to the examination it is essential that the test sound employed shall act upon the organ under examination alone.

We begin, then, by placing the patient in such a position that the ear to be examined is turned toward the source of sound; the opposite meatus is tightly closed by the finger of the patient or, better still, by that of an assistant. To secure perfect occlusion the digit should be previously moistened with water. When the hearing is impaired to a great degree and we have reason to doubt the efficiency of this method of excluding sound from the opposite ear, at the conclusion of the examination of the affected ear, both external auditory canals should be closed and the examination repeated. If now the patient hears equally well with both canals closed, it is evident that the affected ear exerted no influence upon the results obtained by the first tests—in other words, that the ear upon this side is totally deaf. If, however, the results are not the same, the hearing power upon the affected side is obtained by subtracting the perception distance obtained by the last experiment from that elicited by the first.

It is possible, under certain conditions, to convey the sonorous vibrations to the affected ear through a tube, the sounding body being removed to a distance sufficient to prevent perception by the organ of the opposite side. This is particularly valuable if the method is adopted of estimating the hearing power by comparing interval during which the sound is perceived, with that of the normal ear.

---

* Archiv für Ohrenheilkunde. vol. xii, p. 282.

II. **Qualitative Tests.**—We recall that the normal ear perceives vibrations as musical notes repeated at regular intervals from 16 V. D. to about 32,500 V. D. These, then, may be called the lower and upper limits of audition, respectively. When the organ is functionally perfect these limits vary but slightly. When, however, either the perceptive or transmitting mechanism is the seat of a pathological process, these limits are changed in a characteristic manner.

To complete our functional examination, then, it is essential to be provided with some convenient device for producing the lower notes of the musical register—that is, from 16 to 20 V. D. to 64 V. D. per second—and also some instrument which will emit the shrill, high-pitched sound, caused by impulses following each other with extreme rapidity. The first requisite is easily obtained through the medium of a tuning fork of large size. If provided with clamps, a single instrument may, by altering the position of these, be made to vibrate at varying rates. The fork shown in Fig. 61 answers this purpose fairly well. When the clamps are fastened at the extremity of the branches of the fork the instrument makes about 26 V. D. When a little care is exercised in setting the fork in vibration, this note is practically pure and is easily perceived as a musical sound. When the clamps are moved down, so that about half the length of each clamp extends beyond the free extremity of the arm of the fork, as shown by the dotted lines in Fig. 61, the rate of vibration increases to about thirty per second. When carried still lower, the note corresponds very nearly to the contra C of the musical scale. If the clamp is entirely removed the fork emits a pure note corresponding to the next octave higher; in other words, it makes sixty-four vibrations per second.

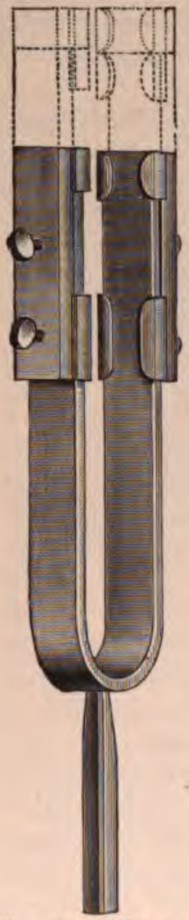


FIG. 61.—The author's tuning fork for determining the lower tone limit. The instrument is provided with adjustable clamps.

While this device does not by any means allow us to examine the lower portion of the scale as thoroughly as we may desire, it reveals very quickly any deficiency in audition for the lower notes of the scale.

The Galton whistle affords a simple means of producing the higher notes of the musical scale, for determining the upper tone limit. This apparatus is essentially a closed organ pipe in which the column of air is set in vibration, either through the medium of the expired air, by holding it between the lips, or, better still, by means of a rubber ball fitted to its open extremity. By a well-known law of physics, if the diameter of a tube is uniform, the note produced by forcing air through it will become higher and higher as the length of the tube diminishes. Thus, if the length is diminished one half, the resulting note will be an octave higher than the fundamental tone of the original tube, and by decreasing the length of the tube gradually, all of the various musical notes may be obtained between the fundamental tone of the tube and that emitted by a pipe of infinitesimal length.

The length of the tube is reduced by a metal obturator, which is slowly advanced along its lumen through the agency of a screw; the outer surface of the tube is graduated, each division of the vertical scale representing the space traversed by the obturator during a single complete rotation of the screw.

Owing to the fact that so many of the instruments sold are not made according to a fixed rule, the graduations of the scale can not be employed in comparing the results obtained by examination with different instruments. It has seemed wise, therefore, to state here briefly the means by which the number of vibrations per second which any instrument of this kind produces may be determined.

The Galton whistle acts as a closed organ pipe, and the variation in pitch of the notes produced depend upon the physical rules which govern the construction of wind instruments of this class. By the law of closed tubes the length of the tube producing a given note is one quarter the wave length. Without going into detail, it will be sufficient to state that in any instrument of this character the number of vibrations per second may be calculated by dividing the velocity with which sound travels by four times the length of the closed tube. Sound travels through the air, at the average temperature, at the rate of eleven hundred and eighteen feet per second; this number, divided by four times the length of the tube which produces the note in question, will give the rate of vibration. In other words, the result obtained by dividing eleven hundred and eighteen feet by the length of the tube, is equal to four times the number of vibrations producing the fundamental note of the tube.

A more exact method of determining the upper tone limit is by means of a series of rods, known as Koenig's rods. These small steel cylinders are of various lengths, the diameter of each being the same. To elicit the primary note of one of these rods it is suspended by means of loops of very light wire or of silk thread, from points equidistant from the two extremities of the cylinder, the location of the points of support being determined by certain mathematical laws. These cylinders are set in vibration by a small metallic hammer and emit a pure tone, the pitch of which varies with the length of the cylinder. This method of determining the upper tone limit is probably more exact than that in which the Galton whistle is used, but it is much more tedious, and for clinical purposes yields scarcely better results.

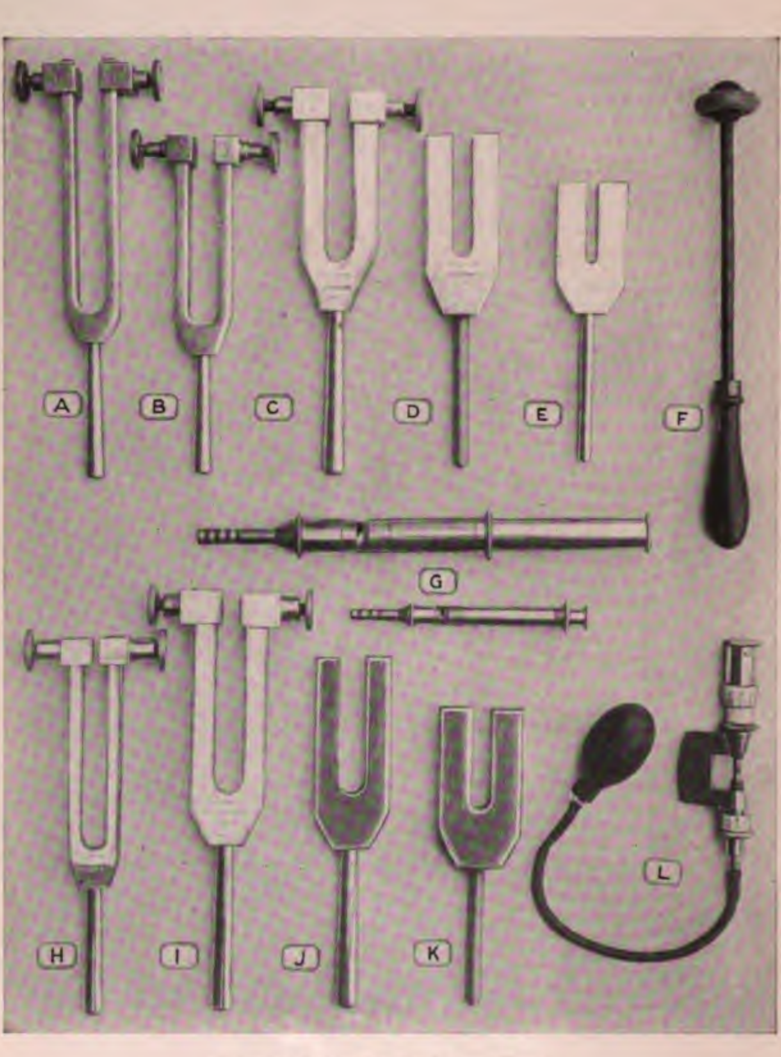
By the low-pitch tuning fork and the Galton whistle we may determine the limits between which musical notes are perceived. Bezold * advises a more exhaustive investigation, and has devised a series of forks and organ pipes by which the complete series of musical notes between the limits of audition can be produced. As the employment of such a number of instruments in examining each case involves the expenditure of considerable time, their use must be confined to the investigation of particular cases, in which so exhaustive a test seems necessary.

The value, as a diagnostic measure, of the next test to be applied depends upon the fact that, under normal conditions, sound waves impress the perceptive centres by the transmission of the sonorous impulses to the labyrinth through the medium of the conducting mechanism—that is, through the external auditory meatus, the tympanic membrane, and the ossicular chain. As a matter of habit, all sounds are best perceived through this avenue, under normal conditions. If, however, the conducting mechanism is obstructed, be the ob-

---

* Arch. für Ohrenheilk., vol. xxx, p. 283.

PLATE VII.



Bezold Continuous Tone Series.

EXPLANATION OF PLATE VII.

A ranges from *d*, 150 double vibrations per second, to *a*, 220 double vibrations per second. This fork unclamped is c^1, 256 double vibrations per second.

H ranges from *a*, 220 double vibrations per second, to d^1, 300 double vibrations per second. Unclamped this fork is g^1, 396 double vibrations per second.

B ranges from e^1, 329 double vibrations per second, to a^1, 440 double vibrations per second. Unclamped this fork is c^2, 512 double vibrations per second.

I ranges from a^1, 440 double vibrations per second, to d^2, 600 double vibrations per second. Unclamped this fork is g^2, 792 double vibrations per second.

C ranges from e^2, 659 double vibrations per second, to a^2, 880 double vibrations per second. Unclamped this fork is c^3, 1,024 double vibrations per second.

J is an unclamped fork, g^3, 1,584 double vibrations per second.

D is an unclamped fork, c^4, 2,048 double vibrations per second.

K is an unclamped fork, g^4, 3,168 double vibrations per second.

E is an unclamped fork, c^5, 4,096 double vibrations per second.

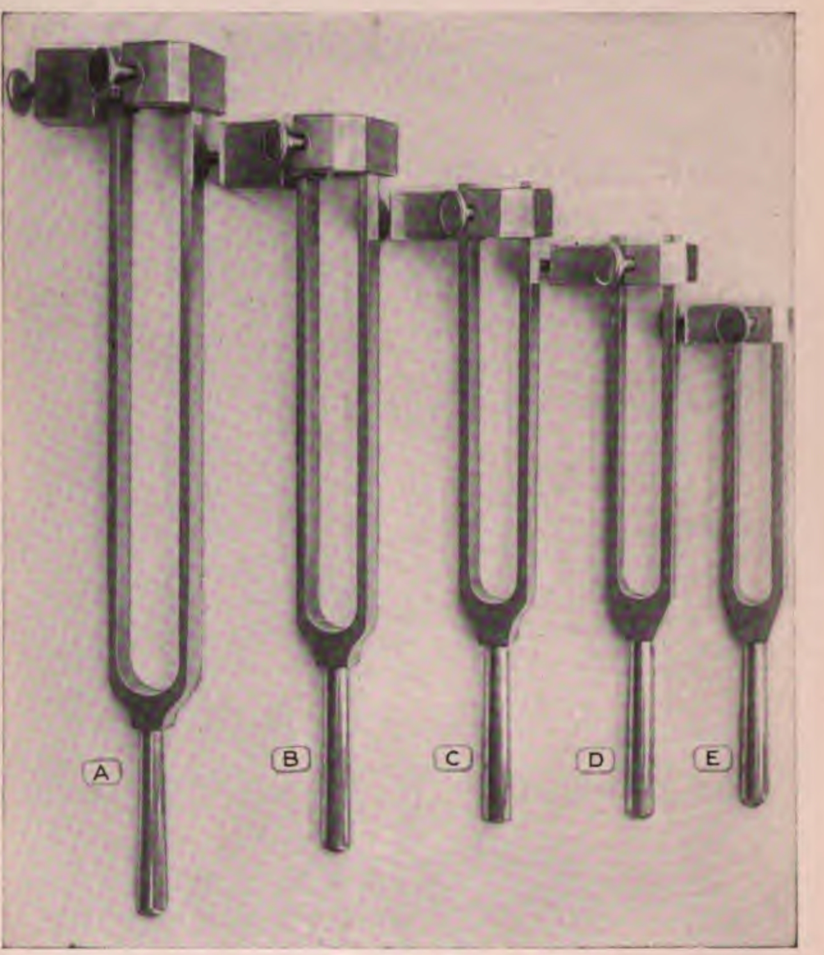
G, Two closed organ-pipes, the larger having a tone range from c^2, 512 double vibrations per second, to a^3, 1,760 double vibrations per second, and the smaller a tone range from a^3, 1,760 double vibrations per second, to a^4, 3,520 double vibrations per second.

L is an improved Edelmann-Galton whistle, having a tone range from 4,000 double vibrations per second to 50,000 double vibrations per second.

F, Hammer for striking forks.

NOTE.—The most recent and complete set of instruments (Bezold and Edelmann, of Munich) consist of a series of ten clamped tuning forks, four unclamped forks, two closed organ pipes and an improved Galton whistle. By means of the tuning forks a practically continuous tone series from 16 double vibrations per second to 4,096 double vibrations per second may be secured. All the forks below g^3 are clamped, thus enabling the investigator to obtain a complete series of tones between 16 double vibrations per second and 1,584 double vibrations per second. Above 1,584 double vibrations per second the forks are unclamped, thus giving a considerably wider range between the various instruments at this part of the musical scale. In the Edelmann series above described, the upper tone limit is determined by an improved Galton whistle, the instrument being modified so as to produce an absolutely pure sound even at the extreme upper limit of audition.

PLATE VIII.



Bezold Continuous Tone Series—Clamped Tuning Forks.

EXPLANATION OF PLATE VIII.

A ranges from C^{-2}, 16 double vibrations per second, to G^{-2}, 24 double vibrations per second.

B ranges from G^{-2}, 24 double vibrations per second, to D^{-1}, 36 double vibrations per second. Unclamped this fork gives the note of C, 64 double vibrations per second.

C ranges from D^{-1}, 36 double vibrations per second, to A^{-1}, 55 double vibrations per second. Unclamped this fork sounds the note of G, 99 double vibrations per second.

D ranges from A^{-1}, 55 double vibrations per second, to F, 90 double vibrations per second. This fork unclamped is *c*, 128 double vibrations per second.

E ranges from F, 90 double vibrations per second, to *d*, 150 double vibrations per second. Unclamped this fork sounds the note of *g*, 198 double vibrations per second.

struction in the canal, in the tympanic membrane, or within the middle ear itself, this path along which the sound waves normally pass is closed to a greater or less degree, depending upon the completeness of the obstruction. Under these conditions, the vibrations must reach the end organ of the auditory nerve by some other path, as, for example, the solid structures of the cranium; and under these conditions a vibrating body held in contact with the cranial bones produces a greater impression upon the auditory centres—that is, is heard more loudly—than when held in front of the external auditory meatus. It is to be remembered that under normal conditions also, when a sounding body is brought into contact with the bones of the skull, the vibrations are perceived. The period during which the sound is heard, however, is much less than the interval during which it is perceived when held before the auditory canal. Roughly speaking, the duration of air conduction is about double that of bone conduction, the air conduction being relatively somewhat greater for the higher notes—that is, a little more than twice that of bone conduction—and the bone conduction, on the other hand, slightly greater for the lower notes of the scale, or a little more than half that of air conduction. Again, the very highest notes are scarcely heard by bone conduction under normal conditions, while the very low notes of the register are felt rather than heard, when the instrument producing them is brought in contact with the head. Age also influences the power of bone conduction, which becomes much reduced after the age of forty-five or fifty years.

Having learned the history of the malady, and determined the physical condition of the ear in the manner previously detailed, and having arrived at a conclusion concerning the extent of impairment by the functional examination, the next step should be to locate the pathological condition either in the sound-conducting or the sound-perceiving apparatus. Many of the methods employed for this purpose bear the names of the investigators who first demonstrated their value. The test most commonly spoken of is that of Weber, who, as the result of a series of investigations, found that when a vibrating tuning fork was placed upon the skull in the antero-posterior vertical median plane and the meatus of one side was closed, the sound of the fork was heard more strongly in the ear which was occluded. In the same way if the structures of the middle ear were bound down by adhesions, if the cavity was filled with fluid, or if the ligamentous tissues were so relaxed that the weight of the drum membrane and the attached ossicular chain constituted an obstruction to the passage of sonorous vibrations from the external canal to the parts beyond—under all of these conditions the vibrating tuning fork was heard better in the obstructed ear. The deduction was inevitable that, in a case in which impairment of hearing existed upon one side alone, or in which impairment existed on both sides to an unequal degree, the perception of the tuning fork from the median line of the head would be stronger in the ear in which the pathological condition in the conducting mechanism was more marked. In other words, the fork would be better perceived by bone conduction in the poorer ear. If the organ upon one side was normal, the fact of the fork being heard better in this ear would locate the pathological condition of the opposite side in the perceptive rather than in the transmitting apparatus.

The second classical test was devised by Rinne,* who was the first to determine that the normal ear perceived a vibrating tuning fork, held before the canal, for about twice as long a time as when the shank of the fork rested upon the mastoid process. In cases where the canal was occluded, or where an obstructive lesion was present within the tympanum, it was found, after the fork had ceased to be heard in front of the ear, that its vibrations could still be recognized when the handle of the instrument was brought in contact with the mastoid. In applying this method of investigation then, if, in a given case in which the hearing is impaired, the duration of bone conduction is greater than that of air conduction, the inference would be that the impairment is due to some lesion of the conducting apparatus, and, pathological conditions of the canal being excluded by physical examination, the location of the morbid process must of necessity be the tympanic structures. If, on the other hand, the hearing is impaired and the normal relation between bone and air conduction is preserved, although both are found to be reduced, the seat of the disease must be the perceptive portion of the organ of hearing.

While both of these facts are of undoubted value, the accumulation of clinical evidence from the investigation of a large number of cases, has convinced those interested in Otology that in many instances they can not rely absolutely upon these reactions to indicate the site of the lesion.

---

* Prager Vierteljahresschrift, 1855, vol. i, p. 71, vol. ii, pp. 45-155.

The first fact with which we are impressed in a careful reading of these experiments is that very little attention seems to have been paid to the pitch of the fork used in conducting the tests. From what we know by experiment (see Physiology) of the effects of increase of tension in the intratympanic structures, or the weighting of these parts or of the tympanic membrane, it can easily be seen that if the impairment of hearing is very slight and the fork used in making the test is of moderately high pitch, an absolute reversal of the relation between the bone and air conduction may not take place, since the application of a load to the drum membrane or ossicles interferes principally with their vibration in their response to the lower notes of the scale. This fact is recognized by Lucæ and by Bezold,* the latter restricting the applicability of Rinne's experiment to those cases in which the whispered voice is not understood at a distance greater than three and a half feet. It must be remembered, that in arriving at this conclusion regarding the application of Rinne's test, a tuning fork making about 512 V. D. was used. By the use of forks of lower pitch the test becomes applicable to cases in which the degree of impairment is much less than this. It is seldom wise, however, to determine bone conduction with a fork of lower pitch than 128 V. D., since a fork lower than this is felt rather than heard, and comparatively few patients are able to distinguish between the two sensations. If a fork making 512 V. D. is used in cases where the impairment is slight, instead of looking for an absolute reversal of the relation between bone and air conduction, a comparison should be made between the time during which the fork is heard when held in front of the canal and that during which it is perceived when placed upon the mastoid. It will be found that bone conduction is increased relatively, although Rinne's test will be positive. Such a result is called "a diminished positive." For clinical purposes, however, it would be impossible to conduct the test in this manner, as the duration periods would then need to be determined with great exactness, and reliable results could be obtained only by complicated apparatus.

---

* Allg. Wien. med. Ztg., 1887, p. 183.

Following in this same line, Schwabach * has found that where obstruction exists in the conducting mechanism, the absolute period of bone conduction exceeds that of the normal ear. Pomeroy,† in applying this test insists upon the ears being tightly stopped with the fingers. In other words, he compares the maximum bone conduction to be obtained from the normal ear with that to be elicited from the organ under examination, combining really the test of Schwabach with that of Weber.

The determination of the absolute bone conduction in seconds, not only consumes considerable time, but the result obtained must vary with the age of the patient, and with different examiners. The variations in the force of the blow setting the fork in vibration also constitute a source of error. It is much simpler, if the examiner possesses a normal ear, to follow the plan suggested by Gardiner Brown,‡ who conducts the test as follows: The tuning fork is set in vibration, and the handle is held against the mastoid of the patient until the sound is no longer heard, this fact being communicated to the examiner by the patient raising his hand. The handle of the fork is then applied to the mastoid of the examiner, and if he perceives the sound, it is fair to assume that the bone conduction of the patient is below the normal standard. If, on the contrary, he no longers hears it, the inference is that the bone conduction is normal. For general purposes, the data obtained in this manner are sufficiently exact, when taken in connection with results arrived at by applying the other tests for determining the location of the lesion.

Reviewing briefly the facts stated in the preceding pages, it will be seen that lesions of the conducting mechanism are characterized by—

I. A loss or impairment of audition for the lower notes of the scale, and as the degree of impairment of hearing increases, the lowest note which can be perceived, or the lower tone limit, as it is called, becomes elevated.

II. The relative duration of bone conduction as compared

---

* Zeitschrift für Ohrenheilkunde, vol. xiv.

† Diseases of the Ear, New York, 1883, p. 337.

‡ Lennox Browne, The Throat and its Diseases, London, 1887, p. 535.

with air conduction increases, the inversion of the ratio being more marked for the lower notes of the scale and affecting these first, the change occurring with the higher notes in proportion as the pathological condition increases, and consequently as the impairment of function becomes more marked.

III. Lesions of the conducting apparatus interfere very slightly with the perception of the highest notes of the scale by air conduction—in other words, have very little effect upon the upper tone limit.

In the same manner diseases of the receptive mechanism are characterized by—

I. No elevation of the lower tone limit.

II. No change in the normal relation between the duration of bone conduction as compared with air conduction, the absolute duration of both, however, being reduced.

III. Absolute deafness for certain notes of the scale, usually in its upper portion, thus frequently lowering the upper tone limit. This is almost invariably the case when the condition is secondary to changes within the tympanum.

Our plan of functional examination, then, is essentially as follows:

The quantitative determination of the hearing by means of:

a. The watch, if the impairment is slight.

b. The acoumeter, if the degree of impairment is more marked.

c. The determination of the hearing distance by means of the "forced whisper" by making use of numbers of two figures.

The qualitative determination of the hearing:

a. The determination of the lower tone limit, using for this purpose the fork already described, illustrated in Fig. 61. The record shows the lowest number of vibrations perceived by the patient as a musical note, the different rates of oscillation being obtained by changing the position of the clamps as already explained.

b. The determination of the upper tone limit by means of the Galton whistle, recording the highest number of vibrations perceived by the patient as a musical sound.

c. The determination of absolute bone conduction.

In determining the absolute bone conduction in any given case the rate of vibration of the tuning fork, as has already been stated, must be taken into account. In patients under forty years of age the most convenient fork to be employed is one tuned to the note "C," making five hundred and twelve double vibrations per second. In patients over forty, a fork making two hundred and fifty-six double vibrations per second gives the most accurate results. For the benefit of those who do not care to make a special study of aural diseases, and hence to whom a multiplicity of devices for determining the actual functional condition of the ear is rather objectionable, it may be well to enumerate the instruments with which satisfactory work can be done.

In the first place, it is necessary to be provided with a low-pitched tuning fork, such as the one shown in Fig. 61, fitted with clamps, by means of which the rate of vibration can be changed by altering their position upon the limbs of the fork. The highest note obtainable with this instrument is one of sixty-four vibrations per second. This instrument will enable the observer to determine defects in the transmission of the lower notes of the scale, a condition which is characteristic of the lesions of the conducting apparatus. It may not be possible for him to determine the lower tone limit, as it may lie above the highest note obtainable with this fork; but if the lower tone limit lies above 64 V.D., the inference must be that the sound-conducting apparatus is not in a normal condition. For the determination of the upper tone limit the observer must be provided with a Galton whistle. The modified form, devised by the author and shown in Fig. 62, gives a greater range than the original instrument of Galton, and is preferable when only a limited number of tuning forks are at hand. This whistle enables tests to be made through a compass of from about sixteen hundred and seventy-seven vibrations per second to about forty thousand vibrations per second, the increased length of the instrument augmenting the compass; it thus supplies the place of the higher tuning forks.

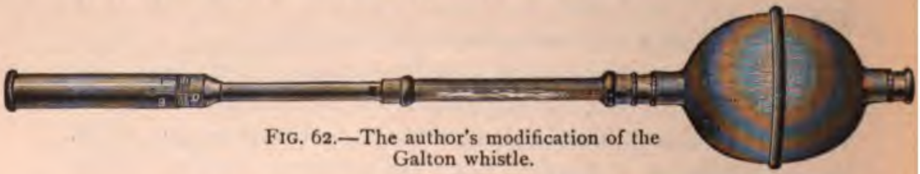


FIG. 62.—The author's modification of the Galton whistle.

For the determination of bone conduction, if but one instrument is to be used, the C fork, making 512 V.D., is the best for general use, since its construction is comparatively simple, and overtones interfere but little with its primary note. The instrument (Fig. 63) devised by Blake, and making 256 V.D., is also exceedingly well adapted to this purpose. In this fork the overtones are avoided by increasing the weight of the branches at their free extremities. With these three instruments a fairly accurate functional examination can be made, and the deductions drawn from the data thus obtained will scarcely ever be misleading. A more extended examination will simply confirm, in most instances, the opinion already formed as the result of the investigation with the above limited number of instruments. It is of advantage, of course, to have appliances at hand for the production of all the notes of the musical scale, and Bezold * has devised a series of tuning forks and of wind instruments which produce musical notes on the principle of a closed organ pipe, and by which the investigator can obtain any note of the scale between the high and low limits of audition. The series consists of eight tuning forks, two organ pipes, and one Galton whistle. Even for a very exhaustive investigation of any case it is scarcely necessary to multiply the armamentarium to this extent, since by means of the low fork already mentioned, together with the modified Galton whistle and the series of five forks recommended by Hartmann † (Fig. 64), perfectly satisfactory work can be done.

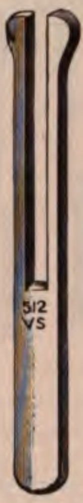


FIG. 63.—Blake's tuning fork. The rate of vibration indicated on the handle (512) refers to single vibrations.

Each of the five forks in this set is tuned to the note C; the lowest fork making one hundred and twenty-eight vibrations per second, while the highest registers two thousand and forty-eight vibrations per second, each fork being tuned an octave higher than the one below it. This particular range is chosen as it includes those fundamental notes which may be called essential to perfect audition—that is, the range of notes employed in ordinary conversation. In addition, the

---

* Archiv für Ohrenheilk., vol. xxx, p. 283.

† Krank des Ohres, Berlin, 1889, p. 32.

Galton whistle will enable an investigation as to the power of the patient to perceive those notes of the scale lying above the highest fork of the Hartmann series. I have employed these instruments for some time, and have seldom been misled in the deductions made from the results thus obtained.

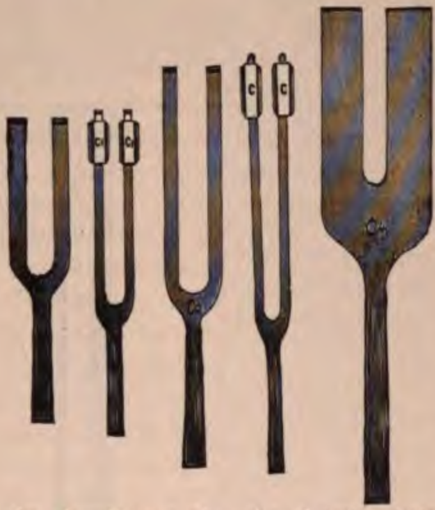


FIG. 64.—Hartmann's series of tuning forks.

In making these qualitative tests certain precautionary measures are necessary: for example, to avoid the production of overtones in using the large tuning fork with the clamps so placed as to produce the lowest obtainable rate of vibration—that is, twenty-six vibrations per second. If care is not taken, an overtone will be produced when the fork is struck, and this may be perceived by the patient to the exclusion of the very low primary note of the fork. In every instance, therefore, the observer should make certain by holding the vibrating fork for a moment before his own ear before it is used to test the patient, that the primary note alone is elicited. It must also be remembered in testing air conduction with tuning forks, that the fork may be held in front of the ear in such position, that its note will not be perceived, on account of the interference of the sound waves, which completely neutralize each other and cause absolute silence. This phenomenon depends entirely upon certain physical facts, as pointed out long ago by Weber.* That this interference may take place the fork is held so that either of the four angles of the parallelogram inclosed by the branches is directed toward the meatus. During the complete rotation of the fork upon its long axis, therefore, there will be four periods during which the note is heard, alternating with four periods of complete silence. It is hardly necessary to say, in conducting the functional examination, that care must in any case be exercised that each of these positions is avoided. Urbantschitsch * has also demonstrated that when the vibrating fork is carried toward the ear from before backward it is not heard as it passes the anterior and posterior margins of the meatus, and the same phenomenon is observed as it passes the superior and inferior boundaries of the meatus, if carried from above downward.

---

* Die Wellenlehre, Leipzig, 1825, p. 506.

In testing absolute bone conduction it often happens that the patient confuses the feeling of vibration communicated by the instrument to the cranial bones with the perception of the tone which it produces. This is particularly true when forks of low pitch are employed in making tests, and in cases of almost absolute deafness. The first error can be avoided by using a fork of higher pitch, the second by bringing the vibrating fork in contact with some other portion of the body, as, for instance, by pressing the handle upon the elbow or knee, and questioning the patient as to whether the sensation is exactly the same as when the instrument is applied to different parts of the cranium. If it is, it naturally follows that he has confused the tactile sensibility with the auditory sense, and his statements are consequently unreliable.

It should also be remembered that the feeling of vibration is much more marked when the handle of the fork is slender than when it is of considerable thickness, and this should be borne in mind in selecting an instrument for testing bone conduction.

In using the Galton whistle the instrument is held close to the entrance of the canal and the current of air is so regulated as to produce the most perfect musical note obtainable with the scale in any given position. Here the individual tested may not distinguish between the blowing sound produced by the air and the high-pitched musical note which he should hear. If the length of the tube is increased so that a distinct whistle is at first heard and then gradually reduced by advancing the obturator by turning the screw, thus producing notes successively higher in pitch, he will easily distinguish the point at which the whistling sound disappears and the blowing or puffing sound is heard. If the screw is then turned in the opposite direction until the whistling

---

* Lehrb. der Ohrenheilk., Vienna, 1890, p. 37.

sound is again perceived, a reading of the scale will give the true upper tone limit. Further, the patient should be made to describe the character of the sound in his own words and without any suggestion on the part of the surgeon, as the latter can easily infer from the reply, whether the impression is that of a musical note or simply the blowing due to the current of air.

It would seem, therefore, a matter of no great difficulty to make a fairly accurate differentiation between diseases of the sound-conducting and sound perceiving-apparatus. We meet with a large class of cases, however, in which both portions of the auditory organ are at fault, the perceptive apparatus being secondarily affected as the result of pathological conditions in the sound-conducting mechanism. Here, then, the results obtained by the above tests may be confusing. In order, therefore, to interpret correctly the data obtained from such an examination, it is necessary to inquire somewhat closely into the causes which are operative in the production of the phenomena already described.

It is conceded that the augmentation of bone conduction in pathological conditions of the meatus and middle ear which cause an obstruction to the passage of sonorous waves inward, is due to the fact that it prevents the passage of undulations outward from the ear when the vibrating body is brought in contact with the cranial bones in the same manner as it offers a barrier to their propagation in the opposite direction when the source of sound is held near the meatus. Steinbruegge * considers that the absolute or relative increase in the bone conduction in these cases is due to a condition of hyperæsthesia of the auditory nerve resulting from the mechanical irritation to which its terminal fibres are subjected. While this condition of increased irritability may be present in many cases, it is certainly not the cause of the increased bone conduction in most instances, other symptoms of auditory hypersensitiveness being wanting in many cases. Further, an examination of the condition of the auditory nerve by means of the galvanic current fails to support Steinbruegge's hypothesis.

Gradenigo † has shown that lesions of the conducting apparatus do in some instances cause the auditory nerve to re-

---

* Archives of Otology, vol. xvii, p. 117.

† Arch. für Ohrenheilk., vol. xxvii, p. 1.

spond more easily to the galvanic current than under normal conditions; and this fact should be remembered, as it enables us to interpret results, which would otherwise seem contradictory, obtained by functional examinations in certain cases.

The experiments of Siebenmann* demonstrate that an increase in the labyrinthine pressure prolongs bone conduction, as evidenced by an examination before and after Valsalva's inflation (the latter procedure, as is well known, increasing the tension of the labyrinthine fluid). In cases where the membrana tympani had been destroyed the labyrinthine pressure was increased by pressing the head of the stapes inward by means of a probe.

We should expect, therefore, to find a prolongation of the interval during which the tuning fork is heard when brought in contact with the cranial bones, in all cases where speculum examination shows either a depressed drum membrane, or the presence of adhesions within the tympanum, drawing the ossicular chain toward the inner tympanic wall. This is usually the case, but occasionally we find that the reverse is true. The latter condition can be explained upon the hypothesis that the condition of increased tension has lasted so long that the function of the auditory nerve has been, to a certain extent, ablated by the mechanical pressure, and that the case is no longer one of intratympanic disease pure and simple, but that an actual pathological condition is present within the labyrinth, dependent upon the disturbance within the middle ear.

When the intratympanic changes are comparatively sudden, as in cases of simple congestion and œdema of the Eustachian tube with displacement of the drum membrane and of the entire ossicular chain inward, we observe that, in addition to an augmentation of bone conduction, the upper tone limit is usually considerably lowered. This is easily explainable when we remember that the highest notes of the scale are perceived by the lowest portion of the cochlea. This portion of the labyrinth, lying as it does in immediate relation to the foot plate of the stapes and the membrane of the round window, will be easily affected not only by changes in the position of the base of the stapes and of the membrana tympani secondaria, but also by circulatory disturbances within the tympanum. It is not strange, therefore, that the very highest notes of the scale should be no longer heard when any sudden change of position takes place in the ossicular chain, or when the tympanic mucous membrane becomes engorged with blood, interfering with the motility of the ossicles. If the interference with the function of the cochlea depends simply upon a slowly increasing pressure, the equilibrium of the labyrinth is but slightly disturbed, owing to the direct communication of both the endolymphic and perilymphic spaces with the lymph channels within the cranial cavity. In such cases, therefore, very little disturbance of the upper tone limit is observed, although the intratympanic structures may be completely bound down by adhesions and drawn inward toward the external labyrinthine wall. The channels of communication, however, between the labyrinthine and intracranial lymphatic spaces are so narrow, that any sudden increase of pressure causes a disturbance of equilibrium in the labyrinthine fluid, and hence lowers the upper tone limit. It is wise, in view of this intimate association between the labyrinth and the tympanum, to repeat the qualitative tests after a restoration of the normal air pressure within the tympanum by inflation, to guard against all possibility of error.

---

* Arch. of Otol., vol. xxii, p. 1.

In addition to the tests given above, mention should be made of certain other methods of investigation which lie at our disposal in making a differential diagnosis. Among the most important of these are the following:

Bing's Experiment.*—This test, first described by the above-named author, is essentially a modification of Weber's experiment. It is conducted as follows: A vibrating tuning fork is applied either to the forehead or vertex in the median line, and is held in this position until its note is no longer perceived. If at this moment the finger is inserted into the external auditory canal of either side, the note of the fork will again be heard. This second interval during which the fork is perceived is called the period of secondary perception for the tone. If the conducting apparatus is normal this secondary perception interval is well marked; while if its duration is shortened, the presence of some obstructive lesion of the conducting mechanism may be inferred. If the interval of secondary perception is of normal duration, while at the same time there is an interference with the auditory apparatus, as evidenced by subjective or objective symptoms, the conducting mechanism must be in a normal condition, and the seat of the morbid process must lie within the labyrinth in the auditory nerve or be due to changes within the cerebral hemispheres or medulla.

---

* Wien. med. Blätter, 1891, No. 41.

Gellé's Test.—Gellé * proposes to test the mobility of the ossicular chain, and especially of the stapes, by compressing the air in the external auditory meatus and observing the effect upon the perception of the note of a tuning fork in contact with the skull. If the foot plate of the stapes is movable, with each condensation of air within the meatus the sound of the fork becomes much diminished in intensity or may be lost, reappearing again as the pressure is relieved. The condensation is effected by means of a small air bag provided with a flexible rubber tube, the free extremity of which carries a conical tip which can be inserted air-tight into the canal. If the labyrinth is affected, either primarily or secondarily, the tone will also be diminished, but the increase in pressure will produce a sense of dizziness and sometimes tinnitus.

Rohrer † considers this test valuable when taken in connection with Rinne's test. According to his investigations, when Rinne's experiment was negative Gellé's test yielded a negative result in seventy-three per cent of the cases tested and a positive result in but twenty-three per cent. When Rinne's test was positive Gellé's test yielded negative results in twelve per cent and positive results in eighty-eight per cent of the cases examined.

The patients selected in these experiments of Rohrer's were cases in which the hearing was very much impaired—so much, in fact, as to make it more than probable that a labyrinthine lesion co-existed with the pathological process within the tympanum. Rohrer lays particular stress upon the value of Gellé's experiment in determining the secondary involvement of the labyrinth following an inflammatory process within the middle ear, in which case Rinne's test very frequently yields negative results; if Gellé's test gives negative results as well, the inference that the labyrinth is affected is fully warranted. In cases where the hearing is very much impaired, and Rinne's test is positive, Gellé's test is also usually positive, if the labyrinth is affected.

---

* Tribune médical, Oct. 23, 1881.

† Lehrb. der Ohrenheilk., Vienna, 1891, p. 66.

Eitelberg's Test.—Another experiment, calculated to differentiate between lesions of the labyrinth and those of the middle ear, is that of Eitelberg.* It depends upon the principle that a nerve continuously irritated by any one stimulus becomes fatigued after a certain time and performs its function less readily. It follows, therefore, that when the perceptive tract is in an abnormal condition this effect will be produced more readily than in a state of perfect health. In performing the test a large tuning fork is made to vibrate in front of the ear for a period of fifteen or twenty minutes, the instrument being set in vibration repeatedly by as nearly as possible the same initial force as soon as its oscillations become weak. If after the nerve has been subjected to this continuous stimulus the perception interval has not been much shortened, the receptive apparatus is assumed to be in a normal condition. As the value of this test depends greatly upon the intelligence of the patient, its application is somewhat limited. A much simpler demonstration of auditory fatigue is constantly presented, in cases where prolonged testing with sounds which are of a similar character as, for instance, the watch, acoumeter, or the whisper yield results which differ greatly from each other, and the ability to perceive the sound steadily decreases as the patient becomes fatigued. We often note a similar condition of the nerve in what may be termed the persistence of an auditory impression; for instance, in testing a patient with the watch it will often be stated that the sound is heard either after the watch has been stopped or has been removed to such a distance that it is impossible for the sound to be heard. This depends upon the fact that an impression once made upon the auditory centres is retained by them for a longer period than normal, demonstrating the fact that they are no longer in a state of health.

Gradenigo's Test.—Gradenigo † finds in cases in which the acoustic nerve-trunk is affected that it quickly loses its power of reacting to sonorous stimuli if the quality of the sound remains unchanged. In other words, the nerve is quickly fatigued. If, however, it is allowed to rest for a short time, it is again able to perform its function. The simplest method of practicing this test is by the use of a tuning fork of about fifteen hundred or two thousand vibrations per second as the source of sound. Such a fork is perceived from fifty to seventy seconds under normal conditions. In cases of torpidity of the auditory nerve, if this fork is set in vibration and held close to the ear its note ceases to be audible after a much shorter interval. If it is now removed a short distance from the ear, for a few seconds, and again carried close to the meatus, it will be again perceived. This manœuvre may be repeated several times during one period of vibration of the fork. It seems that the auditory nerve when in this condition is easily fatigued, but after an interval of rest it may react to a weaker stimulus than that which failed to excite it after it had been subjected to that one for a certain time.

---

* Wien. med. Presse, 1887, No. 10.

† Handbuch der Ohrenheilk. Von Schwartze, Leipzig, 1893, vol. ii, p. 403.

Gradenigo [*] asserts that when the auditory nerve trunk is involved the interference with function is particularly marked for the tones of the middle portion of the scale, the very high and very low tones being well perceived.

In all of these tests, dependence must be placed upon the statements of the patient, and much of the accuracy must depend upon the intelligence and the correctness with which he answers questions. Methods have been devised to avoid the necessity of introducing this element of error in determining the location of the morbid process. Thus Lucae [†] conducted an exhaustive series of experiments with an instrument which he termed the interference otoscope. The device consisted of a tuning fork, the vibrations of which were maintained at a constant amplitude by the action of the electric current. The fork was placed so that its vibrations were collected by a funnel-shaped receiver, the smaller end of which was prolonged as a flexible tube terminating in three branches. One of these terminal divisions was inserted into each external auditory meatus of the patient, while the third was inserted into either auditory canal of the examiner. It is thus seen that the vibrations of the fork would be conveyed through the tubes to both ears of the patient and to the ear of the examiner as well. Any obstruction in the sound-conducting apparatus, as we know, renders the transmission of vibratory impulses more difficult in proportion to the degree of obstruction, and, as the sound perceived by the examiner represents not only the vibrations coming directly to his ear—from the fork—but also the waves reflected from the ears of the patient, it would be possible, by alternately closing the tubes upon the one side and the other, to estimate any variation in the intensity of the sound thus produced. It is evident that the sound would be more intense in proportion as the transmitting mechanism offered an obstruction to the inward progress of the impulses. In other words, the more intense sound should come from the poorer ear if the conducting apparatus alone were affected. Great care must be taken, in conducting this test, that the tubes of the binaural stethoscope shall be exactly equal in length, and also that the ear-pieces shall fit the meatus exactly, in order that all of the reflected waves may pass backward through the tube and into the ear of the examiner. This test has been somewhat modified by Jankau * in the following manner:

---

[*] *Op. cit.*, p. 395.

[†] Arch. für Ohrenheilk., vol. iii, p. 186.

A vibrating tuning fork is placed upon the vertex of the patient and the receiver is dispensed with, while the auscultation tube of the examiner terminates in a Y tube, the free extremities of which join the tubes occluding the external canals of the patient as in the other instrument. Under these conditions the tone conveyed to the ear of the examiner is re-enforced by the action of the external meatus, which acts as a resonator, augmenting the sound of the fork. Under normal conditions, both ears being the same, there is no obstruction to the vibrations through the cranial bones to the labyrinthine fluid, from which they are communicated to the ossicular chain, to the membrana tympani, and in turn to the air in the canal, which re-enforces the sound by its action as a resonator. If, however, an obstruction, due to an increased tension of the labyrinthine fluid, exists, which prevents the passage of the sound waves outward from the labyrinth to the ossicular chain, this resonant action will to an extent be diminished, and the observer will perceive that the sound from this side is less intense. In other words, the weaker sound will come from the poorer ear, if the impairment of function is due to increased labyrinthine tension. If, on the

---

* Arch. für Ohrenheilk., vol. xxxiv, p. 190.

other hand, the vibrations of the labyrinthine fluid are not impeded, but the tympanic structures external to the stapes are in a state of increased tension, the resonant action of the canal will be increased on account of the rigidity of its walls, the condition favoring a more perfect reflection of the sound waves; in which case the stronger tone will come from the poorer ear. Jankau's clinical investigations and experiments seem to confirm this supposition.

The difficulty of avoiding errors of experiment are so considerable here that the chief use of the procedure will be as a confirmatory test.

The Galvanic Reaction of the Auditory Nerve.—As has been stated, the auditory nerve differs very little from other special or general structures of a similar nature. In the study of nervous diseases in general, great attention has been paid to the reactions of nerve tissue under electrical stimulation, and the changes in the electrical phenomena which morbid processes cause. Special attention was given by Brenner * to the effect produced by the galvanic current upon the auditory nerve, and he was the first to formulate the reaction of the normal acoustic nerve. According to this author, upon the application of the galvanic current, a sharp sound is produced at the moment of cathodal closure (c. c.), which, as the current is continued, is transformed into a continuous singing sound (c. d.). At the moment of cathodal opening (c. o.) the singing ceases abruptly. Anodal closure (a. c.) produces no sound, and the period of silence is continued as long as the current passes in this direction (a. d.). Upon anodal opening (a. o.) a low sound is perceived similar in quality to that heard at cathodal closure, but of less intensity. The strength of the current in milliampères represents the strength of the current necessary to excite the acoustic nerve. If after cathodal closure the current is allowed to pass for a few seconds and the circuit is then broken, it will be found that a current of less intensity is necessary to excite an auditory impression than in the first instance. The same follows if the experiment is repeated for the third time. These variations in the strength of the current represent the primary, secondary, and tertiary electric irritability of the auditory nerve. Under ordinary conditions, the nerve requires so strong a current to produce an auditory impression upon it, as to make it necessary to conclude the experiment before the reaction is obtained, on account of the pain which the passage of the current causes. The primary irritability, however, should not fall below six milliampères. In conditions of hyperæsthesia the primary irritability will be found much below this figure; while in cases of torpidity of the nerve this normal limit is exceeded.

---

* Untersuch. u. Beobachtungen über die Wirkung elektrischer Ströme auf das Gehörorgan, Leipzig, 1868.

In the absence of a large galvanic battery, a simple storage battery of from four to eight volts furnishes sufficient current to enable one to make all of these tests; it is necessary to combine in the circuit a reliable rheostat and a milliampère-metre. The current obtained in this manner, while not of great strength, is ample for the purpose and possesses the advantage of not being liable to the variations in intensity which we so often find when the dip cell is used.

Some of the dry cells now offered for sale also furnish a convenient means for securing a reliable current with the expenditure of but a trifle. Twelve dry cells furnish a current sufficient for taking the galvanic reactions of the auditory nerve. In no instance should the ear be subjected to the action of the electric current for purposes of either diagnosis or therapeusis without including a rheostat in the circuit, by which its intensity can be controlled. In employing the galvanic current as a means of diagnosis it is also essential that a milliampère-metre be added to estimate quantitatively, the current causing special phenomena.

Considerable difference of opinion exists as to the proper method of applying the electrodes in conducting the tests. According to the choice of the examiner, the electrode applied to the ear may be placed either upon the side of the face just in front of the tragus, or it may be placed over the entrance of the canal, which has been filled with water; or the canal may be filled with water and the electrode immersed in this, care being taken that it is insulated, so as not to come in contact with the walls of the meatus. The circuit is completed by means of a broad electrode placed upon an indifferent region, sometimes on the back of the neck and sometimes held in the hand.

The experiments of Gradenigo * are of considerable in-

---

* Arch. für Ohrenheilk., vol. xxvii, p. 1.

terest, in that they demonstrate not only the reaction of the acoustic nerve to electrical stimuli, but also seem to prove conclusively that auditory hyperæsthesia is not the cause of the lateralization of the tuning fork in affections of the middle ear. The investigations of this writer show that while the sound may be referred to the hyperæsthetic side, it is often lateralized when no hyperæsthesia exists, or the sound may be referred to one side even when hyperæsthesia exists upon the other.

Another interesting result demonstrated by these experiments is the fact that electric stimulation of the nerve of one side often increases the susceptibility of the opposite nerve to the action of the current.

The remarks made concerning the electric acoumeter applies to the employment of the galvanic tests—viz., that although valuable, the method is too complicated to admit of general use, and the amount of additional information gained by it scarcely compensates for the extra time required for its application. We shall therefore rely principally upon the power of audition for lower notes, the hearing power for high notes, the absolute bone conduction and a quantitative determination of the integrity of audition by means of the whisper, in arriving at an opinion concerning the location of any lesion. To these may properly be added either Eitelberg's test or that of Gradenigo, to afford information concerning the ease with which the nervous apparatus becomes exhausted by prolonged stimulation as compared with the normal organ under similar conditions. The data furnished by these latter tests, however, may be frequently quite as well obtained by observing closely the behavior of the patient during a prolonged functional examination. When the perceptive apparatus is in an asthenic condition, it will be found that prolonged qualitative and quantitative tests are followed by a marked diminution in the ability of the patient to perceive a given sound, demonstrating very clearly that the continuous stimulation to which the nerve tissues have been subjected, has ablated their power to a marked extent.

It should be remembered that under normal conditions excitation of the perceptive tract renders it more sensitive in responding to stimuli, as is clearly shown by the experiments of Urbantschitsch.* The statement already made in considering the electrical irritability of the auditory nerve is no less true of the response of the nerve structures to sonorous stimuli—that is, a sounding body allowed to vibrate before one ear may, to a marked degree, influence the perceptive power of the organ on the opposite side.*

---

* Archiv für Ohrenheilk., vol. xxxiii, p. 186.

---

* Urbantschitsch, Lehrbuch der Ohrenheilkunde, Vienna, 1890, p. 417.

SECTION II.

DISEASES OF THE CONDUCTING APPARATUS.

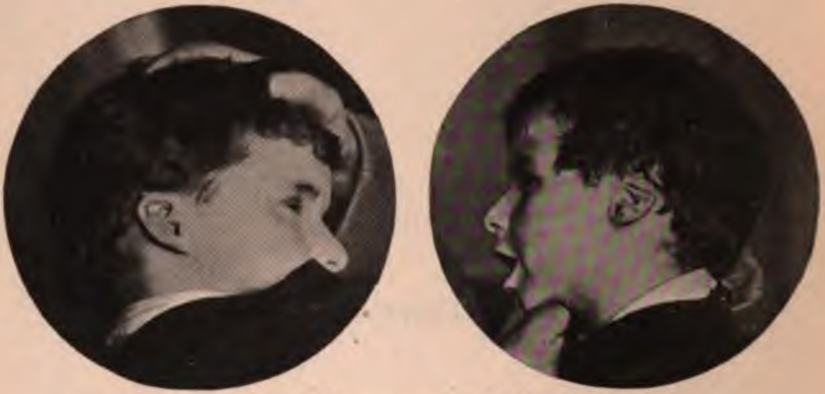


FIG. 64*a*.—Congenital asymmetry and deformity of auricle.

DISEASES OF THE CONDUCTING APPARATUS.

I. DISEASES OF THE AURICLE.

CHAPTER V.

CONGENITAL MALFORMATIONS OF THE AURICLE.

Any malformation of the external ear at birth has for a long time been considered somewhat indicative of the presence of some corresponding mental impairment. That mental weakness, defects, or perversions often accompany such anomalous anatomical conditions is a matter of experience; that the two always occur together, however, is by no means true.

Concerning the classification of these malformations we can divide them into:

I. Deformities of particular parts of the auricle, the external ear as a whole maintaining its general outline.

II. An anomalous shape or a malposition of the entire auricle, including variations in size, or in the angle of attachment to the skull.

III. The presence of some anomalous anatomical condition, such as certain supernumerary appendages, fistulæ, etc., in the region of the ear, the auricle being present either in its normal form or being more or less altered in shape.

IV. A condition of asymmetry between the organs of the opposite sides.

Since the last group is of but little importance, it may be disposed of in a few words. Occasionally we find one auricle either very large, or, on the other hand, while normal in contour, uniformly reduced in size without any other departure from the normal standard. Such a condition can be looked upon only as a "freak of Nature," and is in no way associated with mental impairment, nor can any definite cause be assigned for its existence in many cases. When met with in the adult, a careful investigation of the previous history may reveal some injury in childhood which had been forgotten, and the deformity, which at first was considered congenital, really depends upon a traumatic cause.

I. Deformities of particular parts of the auricle, the external ear as a whole maintaining its general outline.

Anomalies of the Helix.—The so-called Darwinian ear and the satyr ear are examples of moderate anomalies of this character. Wagenhaüser * has reported an instance in which the upper part of the helix was absent on both sides, while Stetter † and Schubert ‡ have reported instances in which the helix was abnormally developed, hanging downward and forward as a flap. In Stetter's case the antihelix was also involved, and the deformity was so extensive as to obstruct the entrance to the meatus. Relief was obtained by a plastic operation.

Anomalies of the Antihelix.—When the antihelix is strongly developed it may project beyond the line of the helix to such an extent as to constitute a deformity. This is most noticeable when the auricle is viewed from behind. Gradenigo has observed this condition more frequently in females than in males, and considers it more common among the criminal and insane than among others. In a case observed by the author the antihelix projected fully one eighth of an inch above the plane of the helix, and a condition of asymmetry was also present, the anomalous condition being particularly well marked upon the left side; upon this side also the lobule was small and terminated abruptly at the antitragus. The intellect was normal.

Sometimes an abnormal development of the superior crus of the anthelix pushes the helix upward and forward, giving rise to what is called the pointed ear.

Anomalies of the Lobule.—The lobule is abnormally large in the black race, reaching such a development among the Kaffirs that by piercing it in a particular manner a sufficiently capacious cavity is formed within the lobule to serve as a pouch for carrying tobacco.

Occasionally the lobule is wanting, as in a case reported by Binder,[*] while Szenes[†] mentions an instance in which the lobule was rudimentary; there was also an absence of the external auditory meatus and a faulty development of the corresponding side of the face. Probably the most frequent deformity in this region is cleft lobule, the appearance resembling closely that seen when the lobule has been torn in the direction of its long axis, by the forcible removal of an earring from the ear.

---

* Archiv für Ohrenheilkunde, vol. xix, p. 55.

† Ibid., vol. xxi, p. 92.

‡ Ibid., vol. xxii, pp. 51, 52.

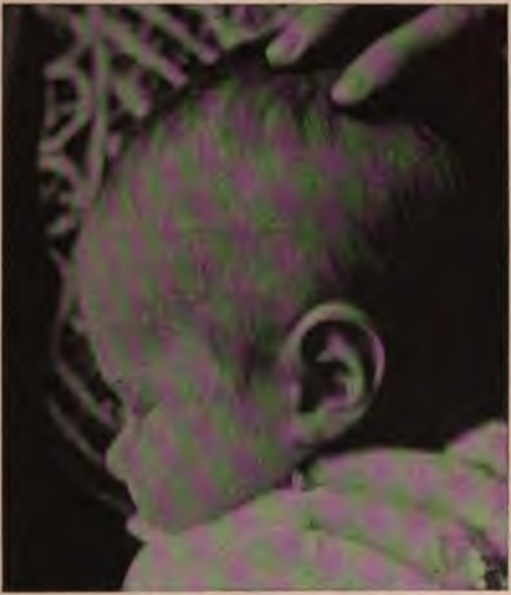


FIG. 65.—Anomalous division of the antihelix into three crura, the lower of which joins the crista helicis. (From a photograph.)

Anomalies of the Tragus.—The tragus may extend backward and be of such size as to offer an actual obstruction to the entrance of sound waves into the meatus. McBride[‡] has observed a case in which there was a rudimentary tragus associated with other abnormities of development.

Anomalies of the Antitragus.—Malformation here is exceedingly rare. Szenes[#] observed an instance in which two spurs of cartilage projected from the antitragus into the canal.

---

[*] Arch. für Psychiatrie, 1887, vol. xx, p. 2.

[†] Arch. für Ohrenheilkunde, vol. xxiv, p. 185.

[‡] Edinburgh Med. Journal, April, 1881.

[#] Arch. für Ohrenheilkunde, vol. xxvi, p. 140.

II. An anomalous shape or a malposition of the entire auricle.

This condition in its most pronounced form is commonly known as microtia, and depends upon an arrest or perversion of the process of development which results in so complete a malformation that the distinctive parts of the external ear are no longer well defined. The condition may be unilateral or bilateral, and is frequently associated with co-existent malformation of the deeper parts of the auditory apparatus. For this reason the condition merits special attention. Microtia is associated in the majority of instances with a complete absence of the external auditory meatus, or, in cases where the canal exists, it is a rudimentary structure; the ossicular chain is frequently poorly developed or absent, and an anomalous condition is common in the labyrinth as well.

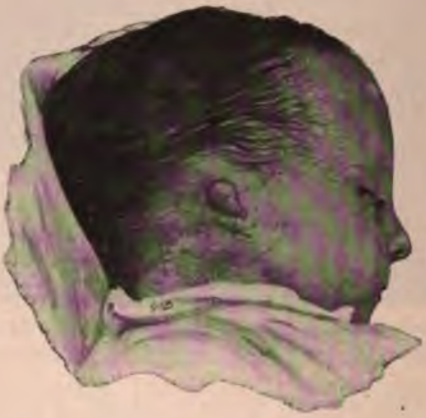


FIG. 66.—Microtia.

The deformity may not be confined to the ear alone, but the entire side of the face may be poorly developed. The appearances vary greatly in different cases, and an attempt to describe them would be but a recital of particular instances.

Fig. 66 is a photograph of a patient dying a few hours after birth. This case was observed by a colleague, to whom I am indebted for this photograph. As may be seen, there is marked deformity of the external ear, the upper portion of the auricle being folded forward upon itself, so that the helix was adherent along its antero-superior border, to the integument in the preauricular region.

Fig. 64*a* shows a congenital asymmetry and deformity of the auricle, while in Fig. 65, there was an anomalous division of the antehelix into three crura.

Treatment.—Where the deformity is but moderate an attempt at correction by a plastic operation may be made in early childhood. Regarding any attempt to form an artificial meatus, the results have been so unsatisfactory that it is seldom desirable to operate for this purpose. If the rudimentary canal is present, its size may be increased by surgical measures, but the frequent malformation of the deeper structures commonly renders the operation futile in improving the function of the organ. If any attempt is to be made to restore the patency of the canal, it should be delayed until the patient is old enough to give information in regard to the power of sound perception either through the air or through the cranial bones. The technique of the operation for re-establishing the meatus will be described under polyotia. The plastic operation on the auricle for the relief of the deformity, however, may be done very early. When a high degree of deformity is present, it seems advisable to excise the entire auricle and supply its place by an artificial device rather than attempt its restoration by surgical measures, which will at the best leave a misshapen organ.

From a practical point of view, one of the most interesting conditions included in this group is that in which the angle between the organ and the lateral aspect of the skull is considerable. This constitutes a deformity amenable to treatment, and, especially in the female sex, one for which we are occasionally consulted. If noticed in infancy, or even in early childhood, the simplest plan for correction is to coat the posterior aspect of the auricle and the adjacent cutaneous surface of the head with collodion, the ear being then pressed to the side of the head and held in position until it adheres. If necessary, several light strips of gauze may be passed over the top of the auricle, holding it closely to the side of the head, and fastened with collodion. Persistence in this plan of treatment will usually be successful in correcting the condition. In adult life little can be gained by this method, and resort must be had to some operative measure. This is best effected by removing an elliptical segment of the integument from the posterior surface of the auricle, the posterior incision passing just beyond the line of attachment to the auricle; the integument is then dissected up from the posterior surface of the auricle for a sufficient distance to permit of an approximation of the edges of the wound. Occasionally it is necessary to excise a segment of the cartilaginous framework as well, in order that the ear may be restored to the proper position. Usually the difficulty is sufficiently well overcome by approximating the edges of the cutaneous wound without removing any of the cartilaginous framework, the tension due to the elasticity of the cartilage being easily overcome by the sutures. Under aseptic precautions and with care, a perfect position can be secured. General anæsthesia is usually necessary, although it is possible to perform the operation under local anæsthesia. It is well to operate upon the two organs separately, using the first as a standard to which the other is made to conform.

III. The presense of some anomalous anatomical condition, such as supernumerary appendages, fistulæ, etc., in the region of the ear, the auricle being present either in its normal form or being more or less misshapen.

Auricular Appendages, the General Form of the Ear being preserved.—Abnormities belonging to this class are the simplest with which we have to deal. The most frequent region for the appearance of supernumerary appendages is the region of the tragus. A case of this sort occurring in my own practice is shown in Fig. 67. The prominent cartilaginous process constituting the deformity was located just above the right tragus, was about three fourths of an inch in length, and projected forward and outward. The tragus itself could be felt, but was rudimentary.

Barth* cites an instance in which a rudimentary mammary gland was located just below the lobule upon one side.

A condition belonging to this class constitutes what is known as "fistula congenita auris" (Fig. 68). Its occurrence is due to an arrest in development of the auricle itself, or, as is believed by some, it indicates an incomplete closure of the first visceral cleft during fœtal life. That this is considered a somewhat rare malformation is probably due to the fact that it seldom gives rise to symptoms, and consequently many cases pass unnoticed. Four cases of this deformity came under my own observation during a period of about a year. Fig. 68 represents an appearance which is fairly typical. The deformity may occur either upon one side alone, or it may be bilateral. In one of my cases the fistula was located just above the tragus, while in another the orifice of the tract was situated one inch above this point and presented an opening about one sixth of an inch in diameter through which a probe could be passed downward and inward for half an inch. On the opposite side the site of the fistula was occupied by a shallow depression which did not admit even the finest probe. Occasionally a slight discharge exudes from the orifice of the fistula, and in a case reported by Pflüger* the appearance of a purulent discharge from such a source was always preceded by acute pain in the ear. Where the walls of the sinus secrete, a blocking of the orifice may cause a retention cyst of considerable dimensions. An instance of this is cited by Urbantschitsch.† The most common location for such fistulæ is in the vicinity of the tragus, although they are occasionally

---

* Virchow's Archiv, vol. xii, part iii.

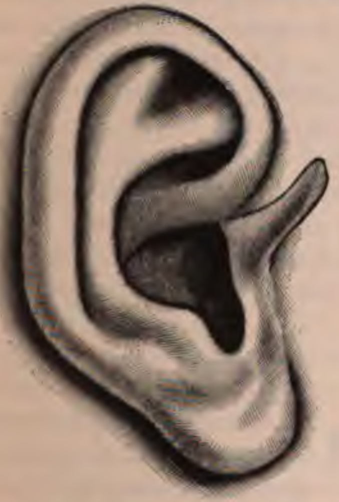


FIG. 67.—Auricular appendage.

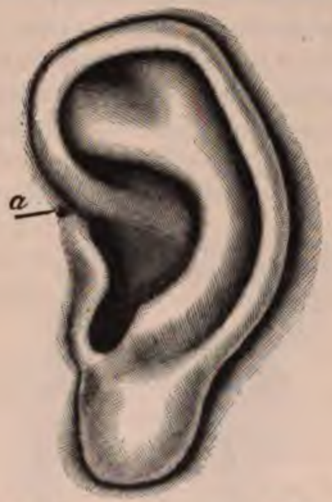


FIG. 68.—Fistula congenita auris. (*a*, fistula.)

---

* Monatsschrift für Ohrenheilkunde, 1874, No. 11.

† Lehrbuch der Ohrenheilk., third edition, 1890, p. 94.

met with in the helix and in other localities. Burnett [*] states that these fistulæ may lead into the tympanic cavity.

Treatment.—The appendages should be removed by means of the knife. The operation is exceedingly simple. When they present in the region of the tragus it is well in excising the growth to form a tegumentary flap from the covering of the anterior surface of the appendage, which can be folded backward over the stump, bringing the line of the suture close to the entrance of the meatus, as the cicatrix is less visible in this position.

Fistula congenita auris demands no treatment excepting in those instances where a retention cyst has been formed by the occlusion of the orifice of the sinus. This condition is relieved by a simple incision and the evacuation of the contents of the tumor, the walls being curetted with a sharp spoon to secure an obliteration of the cavity.

Polyotia.—This term is applied to a congenital deformity in which, in addition to microtia, certain supernumerary growths are met with in the immediate vicinity of the ear, but entirely distinct from the deformed auricle. Occasionally they occur with a perfectly normal auricle, the fact that they are not attached to it distinguishing them from the auricular appendages already described. The condition is sometimes associated with congenital aural fistula, as in the case reported by Bürkner.[†] The deformity may be bilateral or unilateral, and the supplementary organ may present a variety of shapes, the most common being that of a small wartlike excrescence situated upon the cheek in front of the external meatus. When this multiple deformity exists there is usually considerable variation in

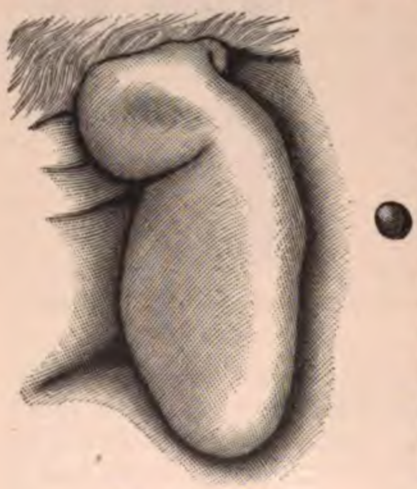


FIG. 69.—Polyotia.

---

[*] A Treatise on the Ear, Philadelphia, 1884, p 211.

[†] Archiv für Ohrenheilkunde, vol. xxii, p. 200.

size and shape between the members of the group. As already stated, a normal auricle is seldom found, although this may be the case. The condition usually occurs in connection with microtia. An instance of this kind, observed by me, is depicted in Fig. 69. The auricle upon the affected side was represented by a cutaneous fold, beneath which there was a cartilaginous framework. This was bent forward upon the cheek, covering the normal site of the meatus. Upon the posterior surface there was a well-defined groove between the cartilaginous and noncartilaginous portion. About three fourths of an inch in front of the anterior margin of this deformed auricle was a small, wartlike prominence representing a second and rudimentary pinna, it being situated too far anteriorly to represent the tragus. The fibro-cartilaginous lamella already mentioned was freely movable, and just beneath its attachment a slight depression could be felt. It was impossible to determine whether the external auditory meatus was present or not. The ear of the opposite side was normal.

The remarks made under microtia, regarding a faulty development or a complete absence of the deeper portions of the auditory apparatus apply equally well to the condition of polyotia.

Treatment.—The small supernumerary appendages are usually easily removed, where they are large enough to constitute a serious deformity. The disfigurement which they cause is usually slight, however. For a correction of the larger malformed mass remaining, a plastic operation may be attempted, although, as in microtia, more satisfactory results may be expected by a complete removal of the deformed member, its place being supplied by an artificial substitute. Concerning the establishment of the meatus surgically, the remarks already made under microtia apply equally well here. Even if it is possible to construct the meatus, it is scarcely possible to secure a condition of permanent patency. When it seems desirable to attempt this operation the technique is as follows:

The field of operation being rendered thoroughly aseptic by shaving the parts and cleansing them with soap and water, and subsequently with ether, an incision is made just behind the attachment of the deformed pinna. The soft parts are divided, exposing the bone, after which the anterior flap, including the periosteum, is turned forward upon the cheek, exposing the region normally occupied by the external auditory canal. A thorough search must next be made for any opening in the bone which may represent a rudimentary meatus, and if such a channel is discovered it should be cautiously enlarged, by means of either chisels or burs, the latter being propelled by an ordinary dental engine or an electric motor. When no fistula is present the bone may be cautiously excavated in the region corresponding to the proper position of the meatus. Great care is necessary during the entire procedure, as damage may be done to important adjacent structures. After the canal has been formed our means for securing its patency will consist in the insertion of an aluminium or rubber tube, which will separate the opposite raw surfaces and allow the deep parts to be thoroughly cleansed, during cicatrization. As the anterior flap when replaced would cover the newly formed channel, it should be perforated over the orifice of the meatus by making two incisions bisecting each other at right angles. Four triangular flaps are thus formed, which are to be inverted into the orifice of the canal and maintained in position for the first few days by a gauze packing, after which the metal or rubber tube already mentioned is to be employed. As soon as healthy granulations spring up, a method which suggests itself as exceedingly feasible would be Thiersch's method of skin grafting, as we might thus hope to secure a tegumentary lining to the passage and prevent its contraction during cicatrization. Such an operation should only be performed at the earnest solicitation of the parents, in the case of a child, or, if the patient has reached adult life, only after the extreme uncertainty of the result has been fully explained.

CHAPTER VI.

WOUNDS AND INJURIES OF THE AURICLE.

It is seldom that we see incised or punctured wounds in this particular portion of the body, although occasionally we are called upon to treat deformity which has resulted from wounds of this character inflicted at some preceding period. Here the ordinary rules of plastic surgery will enable us to secure satisfactory results. In performing any plastic operation upon the auricle it is well to remember that when the entire thickness of the external ear is involved all sutures should be inserted upon the posterior surface of the organ, accurate approximation of the cutaneous edges being secured by passing the stitches deeply into the cartilaginous framework, but not bringing them out through the integument covering the anterior surface.

In the treatment of lacerated wounds, which are more frequently met with, we should attempt to save as much tissue as possible, erring rather in this direction than in that of removing any part which possibly may possess sufficient vitality to survive. The edges of the wound should be thoroughly cleansed, and as a primary procedure a few sutures may be applied, holding the parts as nearly as possible in their normal position. It is a simple matter after the circulation has been thoroughly re-established to secure a more exact approximation and relieve whatever deformity may be present. As the auricle is composed so largely of cartilage, any severe bruising of the tissue is likely to be followed by a sharp perichondritis, and unless there is so much laceration as to contra-indicate the plan, it is well to anticipate such an attack by the employment of cold locally for the first twenty-four hours after the injury has been received; subsequently proper attention may be given to the correction of deformity.

Contused wounds of the auricle without laceration of the integument are of frequent occurrence. Such an injury results either in the formation of a hæmatoma—an effusion of blood beneath the perichondrium—or in an acute perichondritis; in either case the appearance is almost identical. The injured region is occupied by a somewhat spherical tumefaction, the normal outline entirely disappearing. Upon palpation we discover that the contents of the tumor are evidently fluid. The surface varies considerably in color, according to the particular manner in which the injury was inflicted, and, to a less extent, the character of the fluid contained. If this is blood, the surface is of a dull deep-red color, while if the tumefaction is an evidence of a perichondritis, with an effusion of serum, the surface is of a much lighter tint, being either of a bright-rose tinge, or occasionally not differing widely from the integument covering the unaffected portion of the member. Either condition may remain quiescent for a long period; may disappear spontaneously, leaving but slight, or marked deformity; or, as a third possible termination, the contents may suppurate and be evacuated spontaneously.

Where the contents consist of extravasated blood the cartilaginous framework has usually been fractured, and certain portions will almost inevitably become necrotic and exfoliate with the production of considerable deformity. On the other hand, a simple perichondritis, where no fracture has taken place, may disappear without seriously changing the contour of the ear.

Among professional wrestlers and boxers, the ear is frequently subjected to violence not sufficient to produce an acute perichondritis, but enough to cause a mild inflammation of the perichondrium, so slight as to give rise neither to discomfort to the patient nor to appreciable deformity immediately after the injury. This chronic inflammation finally gives to the ear an appearance which is somewhat characteristic, known as " prize-fighter's ear," all the delicate outlines of the anterior surface of the pinna being obliterated by the deposit of new tissue in various localities. Occasionally the deformity reaches such a high degree as to resemble closely the condition resulting from a severe acute perichondritis with cartilagiuous necrosis.

Treatment.—The treatment of an acute perichondritis resulting from contusion consists, first, in the local application of cold, provided the case is seen within twenty-four hours after the injury has been inflicted. During this period the effusion of serum will scarcely reach any considerable amount, and our efforts should be directed to the purpose of preventing the extravasation of fluid. The most convenient way of applying cold is by means of the ice bag, shown in Fig. 70. The mastoid region should be covered by a pad of cotton so as to support the bag against the posterior surface of the auricle, while the anterior surface may be covered by a small flat ice bag.

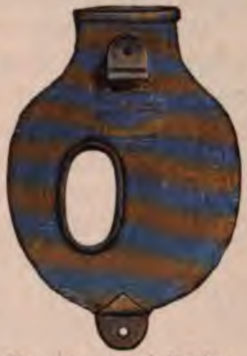


FIG. 70.—Aural ice bag.

When seen at a later period and after effusion has taken place efforts should be directed toward the relief of the deformity. It is a simple matter to aspirate the effused fluid, and cause the auricle to resume a perfectly normal appearance, but unfortunately the result is often but temporary, effusion taking place again very soon. It is scarcely necessary to say that in aspirating the fluid, strict antiseptic precautions as to the instruments and the field of operation should be observed. After the operation, it is well to insure close contact of the surfaces which have been separated by the effusion, by means of a clamp, the simplest device being an ordinary wooden spring clothes-pin, the spring being so weakened as to avoid undue pressure upon the auricle, while the skin is protected by covering the anterior and posterior aspect of the auricle with a thin pad of cotton. Such a device may be worn during the night, and may prevent, to a certain extent, the reappearance of the effusion. The pressure excites a slight inflammation, which may cause adhesion of the separated surfaces and effectually prevent a reaccumulation of fluid. Unfortunately, aspiration is not attended by uniformly favorable results, and after it has failed once it is not advisable to repeat the procedure.

The most radical and satisfactory plan is to evacuate the fluid by a free incision so as to expose at the same time the interior of the sac sufficiently to permit of the proper treatment of its walls. When the fluid has escaped it is well to curette the walls of the sac by means of a sharp spoon, after which the cavity is packed with iodoform gauze, the aim being to obliterate the space by granulation. In opening the cyst, care should be taken to make the line of incision conform with one of the natural folds of the auricle, thus avoiding any deformity from the cicatrix. With proper care in conducting the operation, so as to avoid suppuration, recovery without appreciable deformity is the rule.

When the case is seen at a still later period, and where the injury has been so severe as to result in cartilaginous necrosis, the only procedure available is that of incision. This should be free enough to permit of the removal of all disintegrated cartilage, softened areas being scraped with a sharp spoon until completely healthy tissue is reached. The subsequent treatment is the same as that advocated above.

We have spoken of the various wounds which may occur in this region, and we need mention only those injuries which may be inflicted either by the potential cautery, by chemical agents, or by intense cold. Aside from the destruction of tissue which may result from the action of the potential cautery, or strong acids or alkalies upon the auricle, the effects produced resemble closely those observed after severe contusions, the condition being essentially one of perichondritis. The wounds caused by the various escharotic agents, either potential or chemical, will be treated upon general surgical principles. The most common example of traumatism comprised under this head is that which follows exposure to intense cold. When the ears have been "frozen," if the patient presents immediately, the parts should be restored to their normal temperature gradually, by the application first of pounded ice and then of cold water, the temperature being increased gradually to avoid a sudden disturbance of circulation in the part affected. The ultimate result of a prolonged exposure to cold, may be a perichondritis followed by cartilaginous necrosis and the formation of sinuses upon the anterior and posterior surfaces of the part. Such a condition is to be dealt with surgically; the sinuses must be laid open, all necrotic tissue removed, and the wound be allowed to heal by granulation. If care is taken but little deformity need result.

CHAPTER VII.

CUTANEOUS DISEASES OF THE AURICLE.

Intertrigo.—This disease is observed most frequently in young children, in whom it is caused by the pernicious habit, so common among the laity, of covering the ears and pressing them close to the side of the head by means of a tight fitting cap or bonnet. Among the poorer classes this head-dress is worn for a great portion of the twenty-four hours. This habit is persisted in both in summer and winter, the result being that the cutaneous surfaces of the posterior aspect of the auricle and of the adjacent integument of the head are kept closely in contact, and under the influence of the natural heat and moisture of the body. The result is a desquamation of the superficial epithelium of the integument, leaving the deeper layer of the skin exposed to the air. When this has occurred over a small area the local process becomes intensified from the hypersecretion which takes place from the denuded surfaces, and from the mechanical irritation produced by the child in its efforts to relieve the intense itching. When seen by the physician the adjacent surfaces of the auricle and of the side of the head are reddened and moistened with serum, which has transuded freely. There is no thickening of the integument over the affected area, a fact which serves to distinguish the disease from eczema, which soon follows unless relief is obtained.

Aside from the mechanical causes tending to produce the disease, it is probable that the condition is more commonly found among poorly nourished children than among those who are well cared for. An hereditary predisposition can scarcely be said to cause intertrigo, although it is more common where there is a history of eczema in preceding generations than where such history is wanting, the cutaneous structures apparently, being more easily influenced by a slight local exciting cause, as mechanical irritation, than would otherwise be the case. Lack of proper attention to cleanliness is naturally an important factor as well.

The treatment consists merely in keeping the denuded surfaces apart and protecting them from traumatism. All head gear which would keep these surfaces in contact should be discarded, and the affected areas should be separated by a thin layer of gauze smeared with vaseline, cold cream, or other bland oleaginous medicament. In mild cases merely dusting the surfaces with lycopodium powder, finely divided zinc oxide, zinc oleate, subnitrate of bismuth, or one of the various toilet powders in common use, will ordinarily be sufficient to correct the trouble. These applications relieve the itching, and consequently the child does not interfere with the progress of the disease toward spontaneous recovery.

Eczema.—This disease occurs either as an acute or chronic affection. In all cases probably, there is either some hereditary predisposition, such as a gouty or rheumatic diathesis, or some disordered condition of the primæ viæ, irregular habits of life, improper or insufficient food, etc.

In addition to a predisposing cause some local exciting influence can usually be made out. The most frequent among these is a discharge from the external auditory meatus. This condition, while in the vast majority of cases not leading to an eczema of the auricle, causes the disease in those predisposed to it on account of the reasons named above. Among children the habit of covering the ears, which results, as already mentioned, in an intertrigo, is frequently responsible for the appearance of eczema.

At the beginning of an acute attack there is usually a feeling of burning or discomfort in some portion of the auricle, usually in those regions where the cutaneous surfaces are somewhat closely opposed, as in the fossa of the helix, or in the fissure intertragica, or at the orifice of the meatus, or just behind and below the lobule. In children the region immediately behind the ear is a favorite location. The feeling of discomfort soon changes to one of intense pruritus. To relieve this the patient scratches the part vigorously, increasing rather than diminishing the local hyperæsthesia. The affected surface becomes reddened, soon loses its superficial epithelial layer, is moist from the transudation of serum, or in the later stages may be covered with crusts, the removal of which reveals the bright-red color of the inflamed integument. Instead of appearing in this form, we occasionally have a group of vesicles marking the affected locality. These vesicles, by inoculation from the air, soon become pustular, rupture, and give rise to thick, dirty yellowish crusts, the removal of which is frequently attended by slight hæmorrhage. The condition constitutes a true inflammation of the skin, with infiltration of its deeper layers. Palpation reveals this fact, the integument feeling thick and somewhat stiff over the entire affected area, this sensation diminishing gradually as the healthy integument is approached. Where a local cause is the most prominent factor the affection is unilateral, but where a strong constitutional element is present both organs are affected as a rule. When the disease begins upon the auricle the affection frequently spreads to the canal, producing symptoms which will be described later. Frequently after the disease has persisted for some time the superficial cervical lymphatics are enlarged.

In the chronic form of the disease the entire auricle may be involved, or only limited portions of it. The part affected is either of a dull pinkish color, the surface being glossy and polished, as though the skin were very thin and tightly drawn, or in other cases the superficial epithelium is cast off too rapidly, covering the surface here and there with minute whitish crusts or scales. From the efforts of the patient to relieve the pruritus these scales are picked off, frequently causing a slight abrasion of the surface, and increasing the activity of the local process. On palpation the skin feels hard, leathery, and thick, especially where the patient has subjected it to mechanical irritation for the relief of the itching. Over the unbroken surface the thickened integument has a peculiar smooth, glossy feel. De Rossi* has described a case in which the entire cartilaginous framework of the auricle became necrotic as the result of chronic eczema. It seems probable that there must have been some underlying cause other than eczema, to produce this destruction of tissue.

Treatment.—Our treatment should be directed to the removal of the local exciting cause and to the relief of the constitutional element of which the disease is but a local manifestation. Thus in the acute form the dietary of the patient will frequently need correction, and the elimination of certain articles of food or the addition of others will be followed by satisfactory response to local applications. Diathetic conditions must be managed according to general rules. Moderately large doses of alkalies, either in the form of Rochelle salts, bi-carbonate, acetate, or citrate of sodium, frequently bring about a favorable termination where local treatment alone has been useless.

---

* Archiv für Ohrenheilkunde, vol. xxi, p. 193.

Turning to the local measures to be employed, any discharge from the meatus must receive proper attention, as its presence excites the cutaneous infiltration. In the acute form our first efforts are to relieve the subjective symptoms. To this end cold applications in the form of evaporating lotions are of service. The ordinary lead and opium wash is a favorite remedy in the acute stage, but is disagreeable on account of the color which it imparts to the skin, and because of its characteristic odor. Such objections do not apply to the following:

℞	Liquor plumbi subacetat.	ʒj;
	Bismuthi subnitrat.	ʒss.;
	Morphinæ	gr. ij;
	Glycerini	℥j;
	Aquæ rosæ q. s. ad	℥viij.

M. Sig.: Apply locally as a wet dressing. Shake before using.

Instead of cold applications, better results are sometimes obtained, especially where the thickening is inconsiderable and the discharge from the surface profuse, by employing the local remedy in the form of a powder rather than as a solution. Here we may use the oxide of zinc, subnitrate of bismuth, starch, lycopodium, stearate of zinc, etc. Where the affection causes a most intense burning of the skin an oleaginous substance is the most desirable vehicle. The following ointment may be used:

℞	Bismuth subnitratis	ʒij;
	Acidi borici	ʒj;
	Morphinæ	gr. j;
	Unguenti zinci oxidi	℥ss.;
	Petrolati q. s. ad	℥j.

The same emollient effect is obtained by employing the stearate of zinc in combination with boracic acid and subnitrate of bismuth, and the oily vehicle is avoided.

Owing to the frequency with which any condition attended with an increased secretion leads to the development of an aspergillus within the external auditory meatus, it is advisable if the disease continues for any considerable period and involves the parts about the orifice of the canal, to add salicylic acid to any oleaginous preparation which may be employed as a local application, for the purpose of preventing the development of such a parasite. In order to act in this manner the salicylic acid must be present in the ointment in the proportion of about one and a half to two and a half per cent, a degree of concentration which does not act as an irritant to the sensitive cutis. Eitelberg * has employed an ointment of creolin in the strength of about two per cent with success. Where crust formation is a prominent feature of the affection, as occurs when the acute stage has passed, all aqueous solutions are contraindicated. The crusts should first be removed by softening them with olive oil or vaseline, after which the surface may be medicated either with one of the above ointments or with a proper powder. Salicylic acid in alcohol in the strength of twenty to forty grains to the ounce may occasionally be employed, although in my own experience alcohol has proved of but little service in eczema of the auricle.

It should be remembered that the exposure of the denuded surface to the air is undesirable, and that the affected parts should be constantly protected by some non-irritant or slightly astringent ointment, such as the oxide of zinc, cold cream, or simple vaseline.

Nitrate of silver in aqueous solution has many advocates as a remedy for the disease. It is customary in using this remedy, to begin the treatment with a solution of about ten grains to the ounce, the strength being increased until the desired effect is obtained. I have seen excellent results follow the application of such a solution, after the thickening has been reduced, as the stimulating effect of the astringent lotion hastens the development of a protecting epithelial layer.

Where the thickening of the integument is marked, a condition which must exist when the disease has persisted for any length of time, it will be impossible to effect a permanent cure without relieving the affected area of the serous infiltration.

---

* Wien. med. Press., 1888, No. 13.

It may be possible, without doing this, to cause a temporary improvement, and to succeed in causing the part to become covered with a thin layer of superficial epithelium; as soon as the treatment is discontinued, however, the disease will recur in an aggravated form, and where there is much induration we should direct our attention to this at once. For this purpose the area involved may be thoroughly scoured with green soap, the alkali which this contains causing a temporary stimulation of the surface, through which the tissues are relieved of the serous infiltration, by the free exudation of fluid. This process may be repeated every second or third day until the integument regains its normal texture, after which the use of emollient and astringent applications will cause a speedy return to a normal condition, and effect a permanent cure. A similar result may sometimes be obtained by an ointment containing chrysarobin, or pyrogallic acid, or oil of cade. The ammoniated mercurial ointment also serves a similar purpose. My best results in this class of cases have been obtained by employing the acetum cantharidis, which quickly relieves the engorgement of the deeper layers of the integument, while at the same time the intense pruritus is alleviated. Considerable care is to be exercised in applying this remedy, since if it is used in too large quantities the surface may be blistered and the patient be subjected to considerable discomfort. The acetum cantharidis is to be applied to the affected areas by means of a cotton mop, the parts being first lightly brushed with the solution and the application repeated on the following day if no effect has been produced. As a result of the application of this remedy a free serous transudation takes place, and soon the parts become covered with a normal epithelium, the exuded serum drying upon the surface in the form of a thin yellowish crust, which can either be removed with the aid of the forceps on the second day, or, if left to itself, will become disintegrated and exfoliate as a thin, scaly desquamation. If the action of the cantharides is too vigorous the application of some oleaginous preparation for twenty-four hours will relieve all discomfort. The application of the cantharides may be repeated at frequent intervals until the infiltration has entirely disappeared.

We should add, in closing, that constitutional medication and local applications must go hand in hand in combating the affection under consideration.

Pemphigus.—This is a somewhat rare cutaneous disease, but is occasionally observed. Its characteristic appearance differs in no way from pemphigus developing upon other portions of the body. The condition manifests itself in the formation of large blebs filled with a clear serous fluid. Although the favorite site for the development upon the auricle is the margin of the helix and the lobule, it is occasionally found in other situations.

From local infection, this serous fluid may become turbid, but it is rarely purulent. The bullæ rupture spontaneously at the end of a few days, and if the walls are not destroyed, protect the denuded area which they cover, and are subsequently cast off in the form of scales, their former site being marked by a slight redness of the integument. On the other hand, if the sac is entirely destroyed an eroded surface is left. This seldom persists for any length of time, becoming rapidly dry, the integument remaining slightly reddened in this situation. No pain attends these local manifestations, and the disease is of importance simply on account of the fact that the patient is ordinarily afflicted by several successive crops of bullæ, which are a source of annoyance because of the disfigurement.

The best results are obtained by puncturing the thin envelope which incloses the fluid, and coating the collapsed sac with a layer of flexible collodion to protect the surface beneath. The internal use of arsenic is the best prophylactic measure against recurrence.

Herpes.—This condition is extremely rare, although a search through otological literature furnishes us with quite a number of instances of the affection. The disease is essentially the same as herpes zoster, differing from it only in the locality of the cutaneous manifestation. Neurotic subjects are particularly predisposed to the affection, although it occasionally attacks those in perfect health. Indiscretions in diet, faulty assimilation, and improper and insufficient food may be mentioned among the other predisposing causes. As an exciting cause, exposure to cold is the most important; while in a case reported by Chatellier,* it was caused by local irritation. The particular pathological condition is obscure, but probably consists in a neuritis of the trophic nerves which supply the parts involved. These are the auricularis magnus and the auriculo-temporal, the former coming from the cervical plexus, the latter from the third branch of the trigeminus.

---

* Annales des mal. de l'oreille., 1886, No. 6.

The onset of the affection is commonly marked by severe constitutional disturbance, such as an acceleration of the pulse, an elevation of the temperature, varying in degree from 100° to 102° Fahr., or even 103° Fahr., headache, and a feeling of general lassitude. The characteristic subjective evidence is the intense neuralgic pain, which may be confined to the ear or may spread over the entire side of the face, following the general area of distribution of the nerves involved. Since the pain may precede the eruption by several days, the exact diagnosis is often difficult. When the eruption appears, we find the portion of the auricle involved covered with groups of vesicles which rise from a reddish base and are filled with clear serum. Occasionally they coalesce and form a bullous eruption. The anterior surface of the auricle is generally the region attacked, although in a case reported by Green * the posterior surface was involved. The manifestation is ordinarily unilateral, but Wagenhaüser † observed an instance in which it was bilateral. Although usually confined to the auricle, the affection may spread to the canal. A few days after their appearance the vesicles rupture, their envelope becomes dry and is cast off in the form of minute scales, leaving the integument beneath of a somewhat reddened or brownish hue.

According to Ramsay Hunt‡ a certain form of Herpes Zoster is due to involvement of the geniculate ganglion. In this form of the disease we have not only the herpetic eruption, the pain, and the constitutional symptoms, but we may also have facial paralysis and interference with the vestibular and cochlear branches of the eighth nerve, the former giving rise to vertigo, and the latter to great impairment or perversion of hearing.

Treatment.—Measures directed toward the relief of the condition divide themselves into those for the control of the constitutional symptoms and those for the relief of the local manifestations. Our first measure should be a thorough cleansing of the alimentary canal by a brisk saline purge, the dietary of the patient being at the same time restricted so as to embrace only the simplest articles of food. When the febrile movement is prominent the ordinary antipyretics, such as antifebrin, antipyrin, or phenacetin, should be administered, the last-named drug exerting a favorable influence upon the neuralgic pain. When the pain is of unusual severity, aconitia in doses of one five hundredth of a grain, repeated every hour for three or four doses until the constitutional effects of the drug are felt, after which the interval should be increased to every three or four hours, can be relied upon to give relief. Before the appearance of the eruption, cold applications are grateful. Iced cloths, the aural ice bag, or a cold lead-and-opium lotion may be employed for this purpose. The vesicles are best treated by dusting them with a bland powder to prevent their early rupture, and where they are confluent they may be coated with collodion, for the same purpose.

---

* American Journal of Otology, vol. iii, No. 2.

† Arch. für Ohrenheilkunde, vol. xxvii, p. 159.

‡ Journal of Nervous and Mental Diseases, Feb., 1911, The American Journal of Medical Sciences, Aug., 1908.

If the vesicles are infected and the serous fluid becomes purulent, their contents should be evacuated by means of a small knife, and the exposed area be dusted with iodoform, iodol, dermatol, or touched lightly with a solution of nitrate of silver, to hasten the reparative process. An emollient ointment containing morphine or opium is occasionally of value. It has been suggested, as a rational means of controlling the disease, that counter-irritation, by means of the actual cautery or by vesicants, be employed over the trunk of the nerve involved, but little success has attended this method of treatment. Regarding the subcutaneous injection of morphine over the affected nerve, it should be remembered that disfigurement occasionally follows the use of the hypodermic needle, and it seems that the advantages are not sufficient to warrant the physician urging this plan of treatment.

Syphilis.—Any syphilitic lesion may appear upon the pinna, although a cutaneous manifestation of this constitutional disease is of rare occurrence in the region under consideration. Zücker* has reported an instance in which the initial lesion was situated upon the tragus, the part being of a dark-purplish color, and swollen to twice the natural size. There was concomitant enlargement of the submaxillary and parotid glands.

---

* Zeit. für Ohrenheilkunde, vol. xiii, p. 167.

The erythematous syphiloderm undoubtedly attacks the auricle but, since it causes no symptoms to call attention to its presence, is usually overlooked. The macular eruption is more frequently observed on account of the distinctive appearance to which it gives rise. Occasionally it spreads into the canal, for a considerable distance. According to Taylor,* those parts supported by cartilage are more frequently attacked. The papular syphilide is of interest chiefly on account of the superficial ulcerations to which it occasionally gives rise. In an instance under my own observation such an ulceration had developed at the junction of the lobule with the integument, just below the mastoid. The erosion was sharply defined, the surface only slightly depressed, and but a slight areola was present. The appearance resembled an intertrigo so closely that an exact diagnosis was made only upon the failure of the erosion to clear up under ordinary local treatment, and its prompt disappearance upon specific medication.

A specific eruption of a tubercular character is occasionally observed. The ulcerated areas are covered by large crusts, upon the removal of which the outline of the affected portion is seen to be sharply defined. Either the anterior or the posterior surface of the external ear may be attacked. A correct diagnosis is possible by bearing in mind the sharply defined outline of the specific ulceration, its reddish color in contradistinction from the irregular grayish-white color of tubercular or lupoid ulceration, its slightly depressed surface, which is comparatively smooth, in contradistinction to the nodular appearance observed in the affections just named, and the history of an antecedent specific infection.

The appearance of a gummy tumor in the external ear is one of the rarest manifestations of the constitutional poison. Baratoux † has reported an instance in which the infiltration was multiple. The deposit presents as a hard, smooth tumor, of a deep-red color, and in the early stages does not fluctuate upon palpation. At a later period the centre of the mass becomes necrotic, the disintegrated tissue finally breaking down to form pus, which is evacuated spontaneously, unless prevented by the institution of surgical measures. When left to itself the local necrosis results in the development of a deep ulcer.

---

* Cited by Rupp, Journal of Cutaneous and Genito-Urinary Diseases, Oct., 1891.

† Cited by Rupp, *loc. cit.*

Treatment.—The treatment of specific lesions of the auricle corresponds to that of similar conditions in other portions of the body. If a gummatous deposit is found before disintegration has begun, an effort should be made to cause its absorption, although this at first may seem hopeless.

Where ulceration has taken place before the patient comes under observation, large doses of the iodide of potassium should be at once administered, and for a time local treatment should consist simply in keeping the parts clean, since the reparative process which this drug institutes, frequently preserves tissues which seem so disintegrated that the surgeon would have no hope of saving them. After the internal medication has been persisted in for a short time, and its antagonistic action on the constitutional infection is observed in the ulceration, we should no longer hesitate to remove all those portions which are manifestly beyond repair. The sharp spoon is to be called into requisition, and all softened tissue thoroughly scraped away. The dressing is carried out upon general surgical principles.

Lupus Erythematosus.—This affection usually attacks the auricle secondarily, some other portion of the face being the starting point. At first it presents as a sharply defined reddened area, slightly elevated above the surface of the skin, over which it soon spreads in all directions. The integument involved becomes thick, injected, and separated from the normal cutis by a rather sharp line of demarcation. The surface is frequently traversed by minute veins. Owing to the interference with the blood supply, the superficial epithelium is thrown off more rapidly than under normal conditions, giving the surface a glazed appearance. As the disease encroaches more and more upon the healthy integument, its starting point becomes somewhat depressed and of a lighter color, owing to the gradual sclerosis of the infiltrated tissue. The disfigurement constitutes the entire inconvenience which the affection entails, there being no pain, pruritus, or perversion of sensation. Although usually unilateral, I remember one instance in which the entire face, including both auricles, was involved.

A mistake in diagnosis is practically impossible, although to a certain extent the disease resembles eczema. In the latter affection the intense pruritus, the presence of some local exciting cause, the brighter color of the affected part, and the moist surface, together with the more rapid progress, will usually render a differential diagnosis easy.

Treatment.—Locally we may employ vigorous friction with a strong alkaline soap to relieve the infiltration, after which an astringent or soothing ointment may be applied. Another plan is to employ counter-irritation in the form of tincture of iodine. An ointment containing either iodine and iodide of potassium or pyrogallic acid in the strength of from one to four per cent is also valuable.

In the severe cases, the galvano-cautery, the curette, or even the knife may be employed, although as a rule these vigorous measures are not followed by satisfactory results.

Lupus Vulgaris.—Dermatological literature teaches us that this is one of the rarer cutaneous affections, and its location in the external ear is still more unusual. In the early stages we find upon some portion of the auricle one or more small hard nodules which cause a slight sensation of itching; the efforts of the patient to relieve this abrade the surface of the elevation, which soon becomes covered with a brownish crust. As the disease advances the infiltrated areas increase in size and number. Those which appear subsequently undergo the same changes already described as characteristic of the original deposit.

The progress of the affection is slow but steady. The erosion of the surface gradually becomes deeper and constitutes a true ulceration, the areas of local necrosis being almost immediately covered by brownish crusts which do not separate spontaneously. When the crusts are removed artificially the ulcer appears but slightly depressed, its margins are poorly defined, there is no areola, its boundaries merging imperceptibly into the normal integument. Still later there seems to be an effort at spontaneous cicatrization, which results in considerable deformity due to a shrinking of the cicatrix. The affection does not cease spontaneously, and will almost surely involve the entire auricle unless checked by local measures.

Treatment.—When first seen, it is our duty to remove the involved area as completely as possible, provided the disease is in its earliest stage and limited in extent. In many cases the complete excision of the infiltrated portion of the auricle is the simplest and best measure. Another method is to thoroughly curette away the deposit with a sharp spoon, care being taken that the healthy tissue immediately surrounding the deposit is encroached upon. The curettement should be followed by the application of some chemical agent, lactic acid being probably the best. This should be used in concentrated solution, and should be thoroughly rubbed into the tissues. From the fact that the canal, and even the middle ear, may be attacked if the progress in the auricle is not checked, the surgeon is fully justified in excising the entire auricle if this is so infiltrated as to permit of no other means of eradicating the disease.

CHAPTER VIII.

INFLAMMATORY AFFECTIONS OF THE AURICLE.

Perichondritis.—We have already described an inflammatory condition of the cartilaginous framework of the external ear following an injury to the part. Occasionally such a condition is met with as an idiopathic affection, or is a complication of an acute inflammation of the external auditory meatus. The particular part of the auricle affected will depend largely upon the locality occupied by the inflammatory process in the external auditory meatus, the disease spreading by contiguity of structure, when depending upon such a cause.

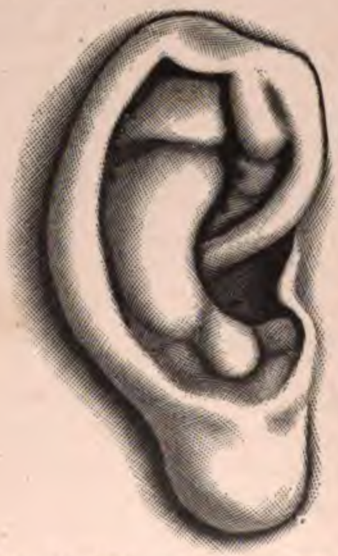


FIG. 71.—Deformity following perichondritis.

The symptoms to which the disease gives rise are a feeling of heat in the external ear, quickly followed by severe pain. The auricle soon begins to increase in size, while over the affected area the skin is of a bright-red hue, due to an increased arterial vascularity. As the disease advances the part becomes more and more swollen, and the normal outline of the auricle entirely disappears. This is due to an effusion of fluid between the cartilage and perichondrium, dissecting this last named structure from the underlying cartilage. The fluid is at first serous, but quickly becomes purulent. The deformity varies considerably, according to the particular area involved. Where the inflammatory condition within the meatus involves the anterior wall, the tragus alone is the part usually affected, while if the circumscribed inflammatory process is situated upon the posterior or superior walls of the canal, the perichondritis is apt to be extensive, and is accompanied by marked deformity. If unrelieved by therapeutic measures the fluid is evacuated spontaneously. In such an event several sinuses appear either upon the anterior or posterior surface of the pinna, and close spontaneously only after a prolonged period. A high degree of deformity is the usual result in those cases which are allowed to progress without surgical interference (Fig. 71).

Treatment.—The treatment of the condition is identical with that advocated in considering perichondritis due to traumatic causes, with the exception that aspiration of the fluid is not admissible, since its purulent character precludes the possibility of a favorable result. In the severe cases the procedure advocated by Gruening [*] of "through-and-through" drainage is probably the most advisable plan of treatment. This consists in thoroughly opening the abscess by means of incisions which pass completely through the substance of the auricle from the anterior to the posterior surface, strips of iodoform gauze being subsequently passed through the openings thus made. In a case under the care of the author the tragus was the part involved, and a rapid cure followed free incision, with a thorough curetting of the cavity.

Erysipelas.—This affection occurs as a complication of facial erysipelas, and requires no special consideration either as regards the clinical course which it runs, or the treatment to be instituted for its relief.

Abscess.—An abscess of the auricle involving its cartilaginous portion constitutes in reality a perichondritis, a condition which has already been described in detail. Occasionally we meet with a localized collection of pus in that portion of the auricle consisting of fibrous and fatty tissue—the lobule. Most frequently the affection depends upon a local infection, either from an earring or following the operation of piercing the ears. Evacuation of the abscess by incision is followed by complete and rapid recovery.

Occasionally we find a superficial abscess in other portions of the auricle, the cartilaginous framework being uninvolved;

---

[*] Archives of Otology, vol. xix, p. 22.

these constitute really retention cysts, and are caused by the blocking up of the orifice of a sebaceous follicle with subsequent disintegration of the retained secretion. In the early stages, when the condition is one of retention only, removal of the obstruction is all that is necessary. After decomposition has taken place, however, the proper procedure is to incise the tumor freely, after which the lining membrane is to be dissected out or thoroughly curetted, to prevent recurrence.

Othæmatoma (Fig. 72).—A transudation of sanguineous fluid beneath the perichondrium is frequently met with as the result of an injury. Occurring, however, without the history of traumatism, the origin of the condition has been a matter of no little speculation. While hæmatoma auris is frequently met with among the insane, numerous authentic reports are found in which the affection has occurred spontaneously, in persons of perfectly sound mind. Age seems to exert but little causative influence, Weil * having reported a case occurring at the age of fifteen months.

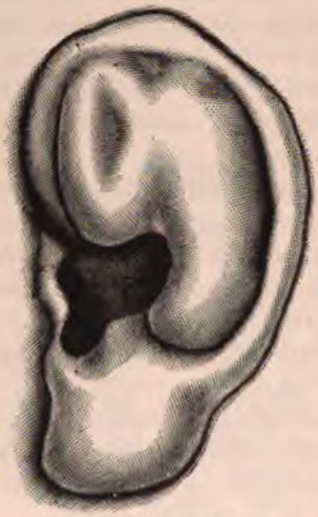


FIG. 72.—Othæmatoma.

The condition is present usually upon one side only, although in a case reported by Brunner † its occurrence upon one side was followed, a year later, by a similar condition in the opposite organ.

From the fact that it has been frequently observed among the insane it is possible that some intracranial lesion may be responsible for its occurrence. The investigations of Brown-Séquard ‡ would add weight to this view, since they show that section of the restiform bodies in dogs will produce the local lesion in question. It is quite probable that in many cases an injury which has been entirely forgotten is the real cause of the pathological condition. Flesch # believes that

---

* Monatsschrift für Ohrenheilkunde, 1883, No. 3.

† Archiv für Ohrenheilkunde, vol. v, 26.

‡ Canstatter Jahresbericht, 1869, vol. ii, p. 27.

Archiv für Ohrenheilkunde, vol. xx, p. 291.

certain variations in the structure of the auricular cartilages predispose to the extravasation of blood, but advances no theory as to the cause of the anomalous structure of the cartilage. It can only be said, therefore, that the ætiological factor in a proportion of the cases is still unsolved.

The affection consists essentially in an effusion of blood, which separates the perichondrium from the cartilage. Occasionally we find, on examining the walls of the cavity, that small plates of cartilage have been forcibly torn from the framework of the auricle during the process of extravasation. The tumefaction appears, as a rule, somewhat suddenly. It may be preceded by a feeling of burning or pruritus, but usually there are no prodromal symptoms. The anterior surface of the auricle is usually involved to a greater or less extent, and the obliteration of the normal outline is correspondingly complete. The integument covering the tumor is either normal in color or, if the effusion is large in amount, may appear pale on account of the pressure.

After its appearance, the effusion may disappear spontaneously, or it may be evacuated by spontaneous rupture, or the contents of the cyst may suppurate. Absorption is so uncommon that we should never wait for its occurrence, while it is probable that traumatism is responsible for the spontaneous evacuation of the fluid in most cases, whether this occurs with or without suppuration.

Treatment.—The treatment varies according to the size of the tumor and nature of its contents, whether this consists of blood alone or whether purulent infection has already occurred.

When there are evidences of pus formation free evacuation should be at once resorted to, the case being treated as one of simple perichondritis.

Where the tumor is small and of recent occurrence, simple pressure by means of a compress held firmly in place by a roller bandage should first be tried. This method, combined with systematic massage of the auricle, is valuable in many instances. In tumors of large size resort may be had to aspiration, followed by the compress, bandage, and massage. Where the effusion is of such proportions as to cause considerable tension of the overlying tissues, evacuation by free incision is the most advisable procedure, the cavity being afterward thoroughly curetted to remove all necrotic tissue and to favor a rapid obliteration of the space by granulation and adhesion. After thus thoroughly removing the contents of the cyst the wound should be packed firmly with iodoform gauze, and subsequently managed according to the rules of general surgery.

It should always be remembered that in the severe cases considerable deformity of the auricle may follow, and the patient should be warned accordingly.

Thickening of the Lobule.—This condition consists of a hypertrophy both of the connective tissue forming the framework of the lobule and of the glandular structures of the region, as the result of a chronic inflammatory process. The most frequent cause of the affection is mechanical irritation, occasioned by the wearing of a ring in the ear, the margins of the artificial opening through which this is passed instead of cicatrizing and becoming covered with normal epithelium remaining denuded, and thus afford an avenue for the entrance of infectious germs. Some metals are easily acted upon by moist air, and are particularly prone to cause such a condition, the products of their oxidation destroying the newly formed epithelial cells and leading to the result above given. When this process has continued for some length of time the pendent portion of the auricle becomes elongated, thickened, tender to the touch, and in some cases the seat of spontaneous pain. The chief annoyance to which it gives rise, however, is the deformity. Occasionally the lodgment of more virulent bacteria upon this denuded surface produces small abscesses.

Treatment.—The treatment of the condition is simple, and consists first in the removal of the local cause. If the deformity has reached a high degree a plastic operation may become necessary for the removal of the superabundant tissue.

Ossification.—Curiously enough, this condition is exceedingly rare, although several instances have been mentioned in otological literature. The causes which may be considered to be active in its production seem to be malnutrition, severe local inflammation, or some profound disturbance of the circulation of the part, such as exposure to intense cold. When osseous tissue has once been deposited, the recognition of the affection is exceedingly simple. The auricle becomes stiff, inflexible, and boardlike to the touch. The ossification may be limited either to a small area or may involve a considerable portion of the organ.

In a case reported by Linsmayer* the bony deposit extended into the floor of the canal. The helix, scaphoid fossa, and antihelix are the regions most frequently affected, and the condition may be present upon one or both sides. Relief is demanded both on account of the deformity and also because of the pain which any pressure upon the rigid organ causes, as when the patient attempts to lie upon the affected side.

Treatment.—The treatment consists in a removal of the abnormal deposit where this is of limited extent. Where a large part of the auricle is involved amputation of the entire organ is justifiable.

Gangrene.—Complete necrosis of the tissues making up the framework and coverings of the external ear is occasionally met with in cases which have not been subjected to any severe traumatism. A marked general cachectic condition, following an acute illness which has lowered the vitality of the patient greatly, or such as may be occasioned by some prolonged suppurative process accompanied by bony necrosis, frequently acts as a predisposing cause. If we combine with such a condition slight but continuous pressure upon the auricle, as might occur in a patient confined to bed for a long period and lying upon one side for a considerable interval of time, the pressure might be sufficient to determine the process under consideration.

Treatment.—The treatment is sufficiently indicated by the causes operative in producing the affection. Supporting and stimulating measures are to be adopted for the removal of the predisposing cause, while care is to be taken to prevent any pressure upon the auricle, bearing in mind the ease with which local nutritive processes are interfered with when the general tone of the body is greatly lowered. If the process has already developed we should attempt, by means of warm applications, to restore the circulation of the region to its normal state, and at the same time to favor spontaneous separation of the necrotic tissue if local necrosis has occurred. Where the necrosis is but superficial, the application of strong chemical caustics may hasten repair, the local irritation exciting a reactive inflammation which in itself becomes a valuable therapeutic measure, causing the early exfoliation of the slough and the development of healthy granulations.

---

* Wien. Klin. Woch., 1889, No. 12.

CHAPTER IX.

BENIGN TUMORS OF THE AURICLE.

Fibroma.—A fibroid tumor is one of the most common of the benign neoplasms which is met with upon the auricle. The lobule is the part usually involved. The negro race is especially liable to the affection, and among this people the growths frequently attain a large size. Local irritation attendant upon wearing ornaments in the ear is the most common exciting ætiological factor. Although the lobule is the part most frequently affected, the concha is occasionally the site of a growth of this character, and in a case reported by Habermann * the external meatus was partially occluded by the tumor, which sprang from the concha.

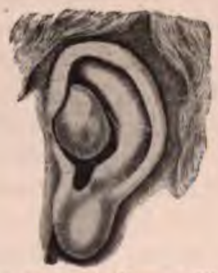


FIG. 73.—Soft fibroma filling the concha. (Anton.)

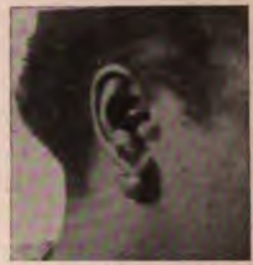


FIG. 73*a*.—Fibroma of lobule. (Author's case.)

Upon physical examination the tumor presents a hard surface, which is usually smooth, but occasionally nodular. Microscopically the mass is made up of dense, white, fibrous connective tissue. In a case reported by Anton † (Fig. 73) the growth was a soft fibroma and contained many connective-tissue cells interspersed between the fibres.

---

* Archiv für Ohrenheilkunde, vol. xviii, p. 76.

† Ibid., vol. xxviii, p. 285.

These growths are of especial interest on account of the fact that they frequently recur after removal, the recurrent tumors occasionally assuming a malignant type, especially after repeated operations of excision have been instituted.

Treatment.—The operative treatment is simple. The mass is to be circumscribed with the knife, the incision extending through the entire thickness of the affected part and lying completely outside of it, within healthy tissue. After the neoplasm has been extirpated the edges of the wound are to be brought together by sutures, and the parts dressed according to general surgical rules. Recovery is usually uninterrupted.

Where the tumor involves the lobule the incision should be so located as to effect the removal of redundant tissue and enable the parts, upon replacement, to be molded into a form symmetrical with that of the lobule of the opposite side.

In addition to pure fibromata, tumors are occasionally met with which are made up of a mixture of fibrous tissue with myxomatous, cartilaginous, or other elements. In a case reported by Haug * the growth was lymphangio-fibroma.

Lipoma.—A true fatty tumor has, so far as I know, never been found upon the auricle itself. They are occasionally met with, however, in its immediate vicinity, usually just below the lobule. Kipp † has reported a case of fibro-lipoma of the concha, the microscope showing the presence of cavernous tissue as well.

Atheroma (Figs. 74 and 75).—A tumor of this character results from blocking up of the sebaceous follicles with which the integument covering the external ear is supplied. The secretion which the glands produce is imprisoned by the stenosis of the orifices of the ducts, dilates the gland cavity, and gives rise to a tumefaction of varying size. Where the gland is active, the rapid formation of its product may produce so much pressure as to cause spontaneous rupture. On the other hand, after attaining a certain size the obstruction in the duct may be overcome, allowing a sufficient amount of the contents to escape to relieve the tension without restoring the normal patency of the tube. This process may be repeated indefinitely, and the patient presents with the history of a recurrent discharge from the growth at varying intervals. Again, the pressure may be so severe as to excite an inflammation within the sac, with the consequent production of a purulent discharge.

---

* Archiv für Ohrenheilkunde, vol. xxxii, p. 161.

† Transactions of the American Otological Society, vol. iii, part iii.

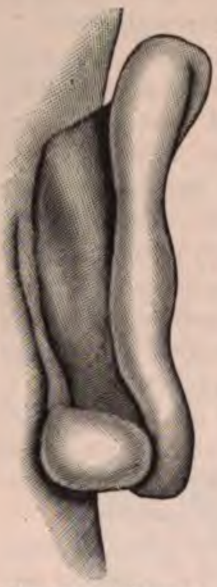


FIG. 74.—Atheroma.

The lobule is a favorite seat for these growths, or the junction of the lobule with the skin of the neck. Marian * has reported a case in which the neoplasm filled the concha. Where spontaneous evacuation has not taken place dissection usually reveals a distinct sac. Where the contents of the cyst have undergone infection and rupture has occurred as the result of an inflammatory process, the lining membrane is usually so amalgamated with the surrounding tissues as to render its recognition as a distinct structure difficult.

Under the microscope the contents of such a tumor is found to be made up of sebaceous material, degenerated epithelial cells, with an occasional admixture of cholesterin crystals.

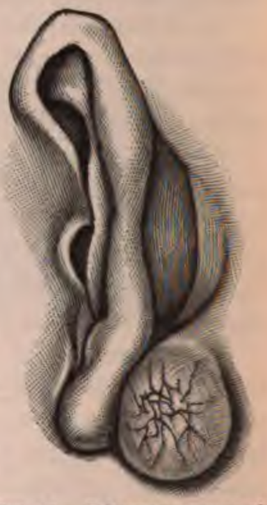


FIG. 75.—Sebaceous tumor of the lobule. (Claiborne.)

Treatment.—This condition is best combated by surgical interference. This consists in the removal of the growth. An incision is made through the overlying integument, and the tumor is shelled out from the envelope without rupture of the sac. In this way a possible recurrence is guarded against. Such a procedure, however, is frequently impossible, the sac being opened and its contents being evacuated in spite of the greatest care. In this event the entire sac should be completely dissected out from the structures with which it has become amalgamated. It is well after making such a dissection to thoroughly curette the cavity by means of a sharp spoon, in order that every vestige of the enveloping membrane may be removed. Where the mass is of but small dimensions and spontaneous discharge has taken place, a thorough curetting of the sac, followed by the application of a strong solution of nitrate of silver, may cause complete obliteration of the cavity and prevent a recurrence.

---

* Archiv für Ohrenheilkunde, vol. xxv, p. 66.

Angioma.—A neoplasm of this character is seldom met with in the external ear, and the reported cases have varied greatly both in the area involved by the neoplasm and in the degree to which the vascular abnormity has developed. In a case reported by Chimani [*] the condition was one of cirsoid aneurism which was present upon the left side of the head at birth, and subsequently extended until a large portion of the auricle was involved, particularly the posterior aspect of the organ. The external ear was displaced outward, and was of a dark purplish-red color; a distinct murmur was perceptible over the growth. The condition improved somewhat under injections of perchloride of iron, although recurrence took place at a subsequent period. The mass was completely dissipated by a repetition of the same treatment.

Occasionally an exposure to cold, as in Kipp's [†] case, seems to be responsible for the affection, although in many instances they are congenital, differing only in degree from the common birthmark or port-wine stain.

Although we do not consider the condition as perilous to life, Jungken [‡] has reported an instance in which hæmorrhage from the growth terminated fatally.

Treatment.—We are usually consulted on account of the deformity which these growths cause, and the measures for their relief must depend upon their size and character, and the coincident presence of a similar condition upon some other portion of the face. When involving only the integument and consisting of a small stain, repeated applications of the galvano-cautery usually obliterate the abnormity. Where the mass is of large size and the vessels are more fully developed, complete excision is the best procedure. This may be effected by seizing the base of the mass with a clamp and removing it *in toto*, ligating the stump in several portions. In other instances the clamp may be dispensed with, and the mass dissected out, the vessels being divided between two ligatures, thus preventing excessive hæmorrhage during the operation. The employment of the ligature to cause the growth to slough away slowly is scarcely advisable.

---

[*] Archiv für Ohrenheilkunde, vol. viii, p. 63.

[†] Transactions of the American Otological Society, July, 1885.

[‡] Schwartze, Ohrenheilkunde, p. 77.

Injections of fluids for the purpose of coagulating the contents of the tumor are not free from danger, since by the dislodgment of a clot, embolism of important vessels may follow, or general sepsis may result.

The employment of the galvano-cautery knife or loop for the excision of such a neoplasm should only be undertaken if a clamp is used, and even if the mass were removed in this manner most would prefer to ligate the pedicle in several portions rather than to trust to a closure of the vessels by the action of the incandescent blade or wire.

Where the tumor increases rapidly in size at the site of its first appearance and other areas of the integument become involved in regions entirely distinct from the original location, we have to deal not only with the lesion as it appears upon the external ear, but by our measures for the relief of this, we should aim to prevent a similar condition from developing subsequently in neighboring regions. This can only be effected, I think, by shutting off the arterial supply of the entire region by the ligation of the trunk from which the various vessels spring. After such an operation the dilated vessels will in many instances be obliterated, while those remaining will be much diminished in size, and any remaining angiomatous masses can be treated upon the rules already laid down.

It should be remembered that the vessels upon one side of the face anastomose freely with those upon the opposite side, and less radical measures than those given above may not be sufficient to obliterate the condition.

Cystoma (Fig. 76).—It is still a matter of discussion as to what particular form of neoplasm this term should be applied. Many use it to designate a localized tumefaction upon the auricle due to a circumscribed collection of fluid not dependent upon traumatism. Many again apply to similar conditions the term hæmatoma or perichondritis, although there may be no evidence of a sanguineous effusion or of an inflammatory process, and although the history may reveal no adequate cause for the occurrence of either affection. The former view seems to me the more tenable and is advocated by Hartmann,* who applies the name of cyst of the auricle to tumors of this description. This opinion is supported by the appearance of the interior of the sac, upon incision of the tumor. There is no evidence of any inflammation of the perichondrium; there are no fibrinous clots, nor any other evidence of a previous traumatism. The development seems to depend upon an effusion of serum simply. Exposed cartilage, however, is occasionally found within the cyst.

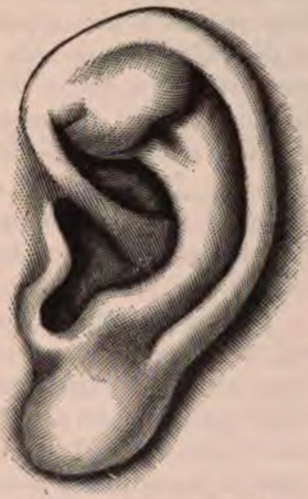


FIG. 76.—Cystoma of auricle.

These tumors make their appearance, as a rule, upon the anterior surface of the auricle, which they involve more or less completely. The overlying integument is normal in color and not tender to the touch. The tumefaction appears quite suddenly, and shows little or no tendency to increase in size, relief being demanded simply on account of the deformity. Harsh manipulation or contusion of the part may cause an inflammation of the cartilage, but this condition is superadded, and not a part of the original process.

The cause of the affection is naturally hypothetical. It may possibly be due to a degeneration in the cartilaginous framework of the auricle, somewhat similar to that which causes the spontaneous development of a hæmatoma auris.

Treatment.—The treatment consists in repeated aspiration of the fluid or of evacuation by incision, after which the cavity is obliterated by packing the wound with gauze. Fischenisch † has obtained good results by massage in these cases. Manipulation in conjunction with aspiration is certainly worthy of trial. After evacuation of the contents of the cyst in this manner the walls should be kept in contact by means of a properly constructed clamp or by a firm bandage.

Certainly the surest method of treating these cases is by incision. This should be made in one of the natural folds so as to prevent deformity. After the sac has been thoroughly cleansed by irrigation, the margins of the incision may be sutured, a few strands of horsehair being passed through the sac to act as a drain. By this method a slight irregularity may remain at the upper and lower extremities of the incision at the points of entrance and exit of the horsehair drain. To avoid this, the entire wound upon the anterior surface may be sutured, and drainage secured by puncturing the cartilage so as to make an opening upon the posterior surface of the auricle. By securing drainage through this channel, and allowing the incision upon the anterior surface to unite by first intention, the probability of recurrence is reduced and all deformity avoided.

---

* Zeitschrift für Ohrenheilkunde, vol. xv, p. 156, and vol. xvii, p. 232.

† Archiv für Ohrenheilkunde, vol. xxv, p. 299.

Papilloma.—Simple papillomata are found upon the auricle only in the form of warts. Two instances of anomalous developments in the epidermal layer have been reported, which might properly be classed under this term. These were observed by Buck,* and consisted of a dense, hornlike protuberance springing from the outer and posterior portion of the helix. In one of these the excrescence attained a length of three fourths of an inch, while the base was nearly as broad. Its growth had undoubtedly been favored by harsh methods of treatment. The mass was removed, and complete recovery followed.

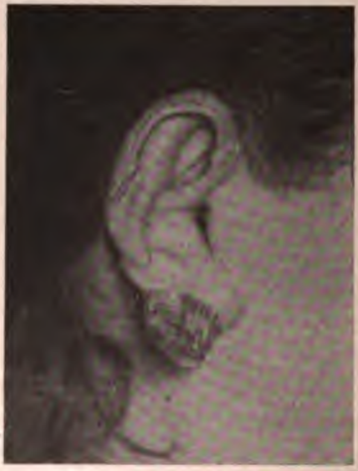


FIG. 76*a*.—Horny growth from lobule. (Author's case.)

---

* Manual of Diseases of the Ear, New York, 1889, pp. 52, 53.

CHAPTER X.

MALIGNANT TUMORS OF THE AURICLE AND OF THE MEATUS.

It is comparatively seldom that the external ear is the primary seat of a malignant neoplasm, although the condition is occasionally met with. Any portion of the external ear may be the site of the primary deposit, from which situation the neoplasm may spread in any direction until a large area is involved. In some instances the growth originates in the external auditory meatus, the auricle being attacked subsequently, or the reverse may be true, the growth appearing first upon the pinna and extending into the auditory meatus.

Malignant neoplasms of the deeper portions of the ear or mastoid process are still more infrequently met with. The most common malignant growth which affects the region in question is epithelioma, sarcoma being of rare occurrence.

Epithelioma.—The same causes operative upon other portions of the body in the production of malignant growths, act here to produce the condition. In a number of instances persistent mechanical irritation has seemed to be the most prominent causative factor. In these cases a slight abrasion of the external ear subsequently becomes the seat of a malignant ulceration on account of the persistent efforts of the patient to relieve the local discomfort to which it gives rise. Individuals under the age of fifty are seldom attacked, although in one instance a malignant growth developed at the age of nineteen.

The progress of these tumors is usually slower than in the other regions of the body, several years being required for them to reach any considerable size. Secondary enlargement of the cervical glands is not ordinarily present, and for this reason the prognosis in malignant disease of the auricle is relatively better than that of a similar condition in other portions of the body. Even where glandular infiltration has occurred there seems to have been little tendency to systemic infection, and removal of the original mass and of the affected lymphatics has been, in the majority of cases, effectual in curing the disease. That systemic infection is so slight in cancer of the external ear is probably due to the fact that the infectious material is absorbed from cartilaginous tissue very slowly, and that the local lesion develops to such an extent that it demands removal before extensive glandular infiltration has taken place.

The physical characteristics are almost unmistakable. No ulceration resembles in appearance that presented by an epithelioma. Before ulceration has taken place it may be impossible to decide the character of the neoplasm, although from the fact that it does not resemble any of the benign growths found here, diagnosis by exclusion is simple.

After the superficial tissues have broken down the eroded surface appears reddened, moist, irregular in outline, and somewhat raised above the healthy integument surrounding it. It bleeds easily on touch, and is frequently tender. Interference with the nutritive supply of the cartilage causes this to become necrotic, and with the process of exfoliation inflammatory reaction occurs. Such a condition is characterized by the presence of exuberant granulations the same as in a simple perichondritis, and during this stage an error in diagnosis may occasionally be made. The true character of the tumor can be made out by removing a small portion and submitting it to a microscopical examination. The removal of a small fragment is easily accomplished by means of the cold wire snare, and this aid to diagnosis should always be employed before a positive opinion is given. On account of the occurrence of exuberant granulation tissue, microscopical evidence of a negative character does not exclude malignant disease, although positive evidence settles the question beyond a doubt.

Treatment.—The results of treatment are unusually favorable. If the mass is removed by radical measures there seems to be slight tendency to a recurrence. Lymphatic infiltration should be dealt with at the same time, and it is only in advanced cases that a fairly favorable prognosis is unwarrantable. The treatment should be the same as that of malignant neoplasms in any portion of the body, early removal by the knife being the only safe procedure. Care should be taken that every vestige of the growth is excised, the incision passing beyond the limits of infiltration and lying in perfectly healthy tissue. The exact plan to follow will vary with the different cases. If the auricle alone is involved, and the infiltration is extensive, it is best to amputate the pinna at once. If possible, when this is done care should be taken to preserve enough of the integument about the orifice of the meatus to permit of its being sutured to the skin of the face, thus securing a patulous external canal lined with epidermis. Where, however, the growth has extended ever so slightly into the canal, the auricle and the entire cartilaginous meatus should be removed. When this is necessary it is almost hopeless to attempt to secure a patent external meatus, although the effort should be made. For this purpose a drainage tube, either of soft rubber, silver, or aluminium, should be kept constantly in the canal in order to preserve its lumen. Such a device may be worn for a long period, and be removed once daily for the purpose of cleansing the passage, being quickly replaced to prevent the occlusion of the canal by the granulation tissue. Even after such a tube has been worn many months the attempt frequently fails. It may be possible in some instances to employ skin grafting, either by Thiersch's method or by twisting a small flap from the adjoining region into the orifice of the canal, and thus secure a proper tegumentary lining. I have tried neither of these methods, since the procedure was not suited to the two cases which came under my observation. In one instance, where the growth involved the posterior wall of the canal, the meatus was completely obliterated in spite of persistent efforts to maintain its patency. In a second case a perfectly patent canal was obtained by uniting the integument of the anterior wall of the passage with the margin of the cutaneous incision through the skin of the face, the cutis being dissected up for a considerable distance to permit displacement toward the meatus. Coaptation of the edges was not attained, and this does not seem to be necessary. The sutures may cut through at the end of a few hours and still perform a very important function, the parts being held in position for a sufficient length of time to become so firmly fixed by plastic effusion as not to retract to any extent after the sutures have given way. In the instance named, a considerable portion of the wound healed by granulation, and there was scarcely any deformity, and but slight contraction at the entrance of the meatus.

In excising a growth of this character involving a large portion of the auricle, a little care will enable the operator to replace the parts in such a manner as to prevent disfigurement. Where the parotid gland is involved, it is seldom wise to attempt extirpation, although in a robust patient it is permissible. As the facial nerve passes through this large glandular mass, it is well to warn the patient of the possibility of facial paralysis following the operation.

No special suggestions are necessary concerning the course to be pursued with the lymphatic enlargements. These are dealt with on general surgical principles. The employment of the galvano-cautery, the cold snare, chemical caustics, etc., for the removal or the destruction of a malignant neoplasm of the auricle seems to the author scarcely justifiable, although many have used the potential cautery upon small growths of this character, with eminently satisfactory results.

Sarcoma.—Occasionally a sarcomatous neoplasm originates primarily in the external ear, or, on the other hand, this organ may be involved by contiguity of structure from a similar growth in the cervical region. The growth exhibits no preference for any particular region, any part of the external ear being equally liable to involvement. Extension to the external auditory meatus has occurred, and the possibility of this should always be borne in mind. Such an extension to the canal renders extirpation of the growth less easy and the possibility of its occurrence constitutes a plea for early operation.

The tumor varies in appearance according to its situation, and differs from an epithelioma in that ulceration of the surface does not take place until a comparatively late period. The mass is less firm than an epitheliomatous tumor, is usually more vascular, the surface being frequently traversed by tortuous blood vessels. The tumor may grow slowly and exist for many years without giving rise to symptoms sufficiently urgent to demand operative treatment; on the other hand, these tumors sometimes increase rapidly in size and demand interference at an early period.

Treatment.—The successful treatment depends upon the complete removal of the growth, and in these cases, owing to the increased vascularity of the mass, it may be wise to employ the cold or incandescent écraseur or the galvano-cautery knife. If the mass is completely removed at the point of primary deposit, recurrence seldom occurs. Systemic infection is rare.

II. DISEASES OF THE EXTERNAL AUDITORY MEATUS.

DISEASES of the external auditory canal may be divided into two classes as regards their causation, duration, and extent.

As regards causation, either primary or secondary.

As regards duration, either acute or chronic.

As regards extent, either circumscribed or diffuse.

While inflammatory changes in this region are often secondary to some coexisting condition of the tympanum, either circumscribed or diffuse inflammation may occur as an idiopathic disease both in the acute and chronic form.

CHAPTER XI.

CIRCUMSCRIBED EXTERNAL OTITIS.

ACUTE CIRCUMSCRIBED EXTERNAL OTITIS.

Otitis externa circumscripta acuta. Furuncle.

Ætiology.—The occurrence of a circumscribed inflammation within the auditory canal is usually due either to mechanical irritation, the result of scratching the ear with the finger or with some blunt or sharp instrument; to inoculation in the same manner; to a loss of superficial epithelium as a result of some cutaneous disease, the abraded surface forming the point of entrance for pathological bacteria; or, where the tympanum is the seat of a purulent inflammation, the local infection may take place through the ducts of the glands with which the meatus is supplied.

It is doubtful, probably, whether all cases are not the result of some local infection, but certain constitutional conditions predispose strongly to the disease under consideration. The local lesion sometimes appears without any discernible source of local infection—in other words, it occurs as an idiopathic disease. Marked impairment of the general health, disturbance of the digestive system, anæmia, and diabetes render an individual particularly susceptible to the malady.

Pathology.—From the anatomical structure of the meatus, it follows that as the external or fibro-cartilaginous portion is freely supplied with glands, this is the part most usually attacked. The inferior, posterior, and superior walls are more frequently affected than is the anterior. Usually the focus of the inflammation is situated near the orifice of the meatus, although it may be located in any portion of the canal, and occasionally is met with in the osseous part. The abscesses occur usually in groups rather than singly, due to the fact, probably, that infectious material from the same source has inoculated several glands simultaneously. The disappearance of one "crop" is apt to be followed by another, thus prolonging the course of the affection. This is especially true where any diathetic condition is present.

Loewenberg* lays great stress upon the fact that certain micro-organisms are found in the pus discharged from these small abscesses. Schimmelbusch,† working in the same line, likewise attributes the local abscess to the presence of a bacillus, but has shown that an abrasion of the normal epithelium is necessary in order that the germ may develop at any point. It has already been stated that an asthenic constitutional condition in many cases predisposes to the formation of these abscesses, the power of resistance to any morbid process under these circumstances being much reduced. There is considerable evidence to show that a trophic disturbance caused by some obscure condition in the nerve trunks which supply the meatus may also be the prominent causative factor.

Urbantschitsch‡ has reported instances where a derangement of the trophic nerves of one side, due to a local lesion, was followed very quickly by the development of a furuncle in that portion of the canal of the opposite side, supplied by the corresponding nerve. I myself have seen two cases which were undoubtedly of a reflex tropho-neurotic character. One occurred in a boy, aged fifteen, who suffered from a severe traumatic external otitis, the abscess being located on the posterior wall of the canal. Notwithstanding the fact that the patient was in excellent general condition, the opposite canal, which was apparently healthy up to this time, was similarly affected about four days after the incision of the first abscess. The identity in the location of the abscess upon either side and the absence of any other exciting cause, seemed to place this second furuncle in the category under discussion. In the second case the development of a small, circumscribed area of inflammation upon the floor of the right meatus was followed within twenty-four hours by an exactly similar condition in the same location upon the opposite side. In this short interval the local process had reached maturity, and when the patient was seen the second abscess was discharging, although the region had been inspected with great care less than twenty-four hours previously, and was, at that time, in a perfectly normal condition.

---

* Deutsch. Med. Woch., 1888, No. 28.

† Arch. für Ohrenheilk., vol. xxvii, p. 252.

‡ Lehrb. der Ohrenheilk., Vienna, 1890, p. 107; Arch. für Ohren., vol. xxxv, p. 5.

We must believe, therefore, that the cause may be reflex in character even in cases where the general health is unimpaired. After infection has taken place, the inflammatory process advances rapidly, the central portion of the affected area losing its vitality and being discharged either in the form of pus or sometimes as a distinct mass of necrotic tissue. Ordinarily the inflammation does not extend deeply by contiguity of structure, but when very severe the underlying tissues may become affected, developing a perichondritis of the canal or auricle. This is particularly apt to take place when the furuncle is located on the anterior wall, the entire tragus becoming involved. Exceptionally, the affection may lead to a diffuse external otitis, which, spreading along the posterior wall of the canal, may give rise to periosteitis of the osseous portion, and may thus by extension involve the middle ear itself. In either event extension to the mastoid cells may occur.

Symptomatology.—The first symptoms with which the disease is ushered in is usually a feeling of fullness or discomfort in the ear, or sometimes a slight itching sensation, causing the patient to press the finger against the tragus. Soon, however, he finds that this part is tender upon pressure, and a little later spontaneous pain in the ear becomes very well marked. At this juncture the hearing becomes considerably interfered with, owing to the stenosis of the meatus resulting from the tumefaction. For the same reason there is frequently tinnitus, usually rather high pitched in character, which increases as the affection progresses. This may be due either to stenosis of the canal or to the congestion of the deeper structures from the increased blood supply. The pain increases in severity, so that within twenty-four hours from the first feelings of discomfort it may be almost unbearable, while the ear continues to be very tender to the touch, especially when pressure is exerted in front of the tragus. From the intimate relation between the cartilage of the tragus and the intermaxillary articulation the motions of the lower jaw are interfered with, and mastication frequently becomes so painful that the patient can take liquid food only. The spontaneous pain is especially severe at night and frequently may prevent sleep, although during the day the patient may be able to follow his vocation. If the abscess is located upon the anterior wall of the canal the parts in front of the ear appear swollen and slightly turgescent. If, on the contrary, the posterior wall of the canal is affected, one of the frequent symptoms noticed is an undue prominence of the auricle, the external ear being crowded somewhat forward and standing out more prominently from the side of the head than does its fellow on the opposite side. When the furuncle is in this location, also, the slightest pressure upon any portion of the pinna causes intense suffering. When the abscess is situated upon the posterior wall, a not infrequent symptom, and one to which the patient is apt to attach undue gravity, is a marked œdema of the integument behind the ear.

Infiltration of the cervical glands, and also of the pre-auricular glands, is of common occurrence, the former giving rise to a hard, irregular swelling extending from just below the lobule downward along the course of the sterno-mastoid muscle to the angle of the jaw, while in the latter case the side of the face immediately in front of the ear presents some irregular induration due to an inflammation of the lymphatic nodules in this region. The parotid gland itself may also participate in this inflammatory process, causing its outline to become distinctly defined both to ocular inspection and to palpation. This is due to secondary engorgement of the gland, and consequently suppurative inflammation of the parotid occasionally complicates a circumscribed external otitis. Occasionally we find directly behind the auricle, a rather prominent group of small lymphatic glands; when these are present a localized inflammation upon the posterior wall of the canal is attended by considerable infiltration of these structures, in which case the œdema before spoken of is replaced by an irregular induration which is so poorly defined in its limitations, that it may be mistaken for an inflammatory condition of the mastoid periosteum.

Constitutional symptoms are, as a rule, not well marked. The attack may run its course in an adult with scarcely any elevation of temperature, or the temperature may be slightly elevated—reaching perhaps 99° or 100°. If glandular inflammation is present as a secondary affection, the temperature is more apt to be elevated than when this does not exist. A feeling of general malaise, headache, loss of appetite, etc., is attributable rather to the loss of sleep and the discomfort attendant upon the condition within the canal than to any actual systemic infection. After these symptoms have persisted for from forty-eight hours to three or four days, they disappear quite suddenly, and coincident with their cessation a purulent discharge appears in the meatus. This, it need scarcely be stated, is due to the spontaneous rupture of the abscess, the discharge of its contents causing an abatement of all the distressing manifestations.

As stated under Pathology, however, these abscesses ordinarily appear in groups, so that in the course of a few days the symptoms already narrated are repeated. If the inflammatory process extends to the tympanum or to the mastoid cells, the pain becomes more intense and the constitutional symptoms also are more marked. The temperature rises, the pain instead of being localized involves the entire temporal region, or may manifest itself as a severe general headache. The impairment in hearing and the subjective disturbances become more marked, and the gravity of the affection is evidenced by the increased prostration from which the patient suffers.

Diagnosis.—It would seem that the diagnosis of such an affection would present no difficulties, but this is frequently by no means simple. In the early stages the patient is not able to localize the pain, but complains simply of a feeling of discomfort and heaviness in the head, and may even ignore the ear entirely and refer all the painful sensations to the presence of carious teeth. An inspection of the ear at this period may reveal absolutely nothing. If, however, we supplement ocular inspection by carefully testing the sensitiveness of the walls of the canal by means of a cotton-tipped probe, usually some one point will be found where pressure causes the patient to wince slightly. Too much stress can not be laid, however, upon the necessity of first inspecting the ear without the use of the speculum, the auricle being drawn upward and backward, or in a very young child downward and backward, and the entrance of the meatus first examined by reflected light before the introduction of any instrument. It is well, also, to press gently upon the posterior, inferior, superior, and anterior walls of the canal with the cotton-tipped probe before introducing the speculum, in order to recognize any tender point which might escape detection after the insertion of the instrument. Very frequently, at an early stage, this tenderness may be the only evidence suggestive of the local lesion. If this examination is made before the speculum is inserted, a very slight tumefaction may be observed encroaching upon the lumen of the canal, from one of its walls. This area may not differ in color from the surrounding parts, or it may be of a slightly pinkish or reddish hue. This alteration in color is seldom noticeable, and the insertion of the speculum may entirely obliterate the local swelling. The deeper parts should be tested, after the speculum has been introduced, by means of the probe in the manner already described, and the presence of one or more tender points be looked upon with suspicion. If the local process is more advanced the areas of tumefaction are easily recognized (Fig. 77); if the inflammatory process is located near the orifice of the canal, the introduction of the speculum may be painful. As many patients, however, wince slightly upon

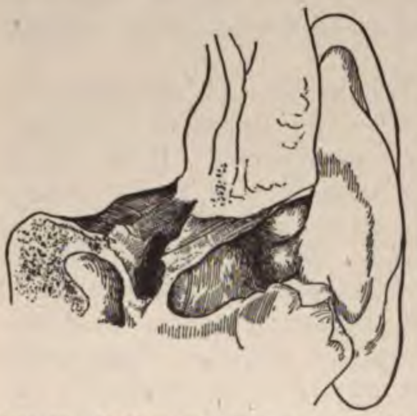


FIG. 77.—Otitis externa acuta circumscripta, at the entrance of the canal involving the superior and posterior walls. (Natural size.)

the introduction of any instrument into the meatus, this sign should be accepted with considerable caution. As has been stated, circumscribed inflammation of the canal is usually located in the movable portion, and although occasionally occurring in the osseous segment, any localized tumefaction in this region should be looked upon with great suspicion, especially if situated upon the superior posterior wall, since in this locality the mastoid antrum is separated from the meatus by a comparatively thin plate of bone, and an inflammation within the mastoid cells often causes an encroachment upon the lumen of the canal in this locality. When this is the condition otoscopic examination gives the impression of a canal which rapidly becomes narrow at the fundus, the line of demarcation between the drum membrane and the superior and posterior walls of the meatus being poorly defined. In some instances only a small slitlike opening is visible at the inner extremity of the canal, the membrana tympani being completely hidden from view except over this area (Fig. 78). Such a condition means, almost invariably, a collection of fluid within the mastoid antrum, and always indicates an affection of the deeper structures, although the process may have had its origin in the external meatus; in other words, the affection is no longer confined to the meatus, but involves the middle ear. On the contrary, in furuncular inflammation the greatest narrowing is at the orifice of the meatus, and if the speculum can once be carried past this obstruction, which lies comparatively near the external opening of the canal, an unobstructed view can be obtained of the parts that lie beyond. Where a circumscribed external otitis occurs in an ear which is already the seat of a purulent inflammation of the tympanum, the location of the tumefaction in the superficial meatus will frequently enable us to distinguish between a simple circum-

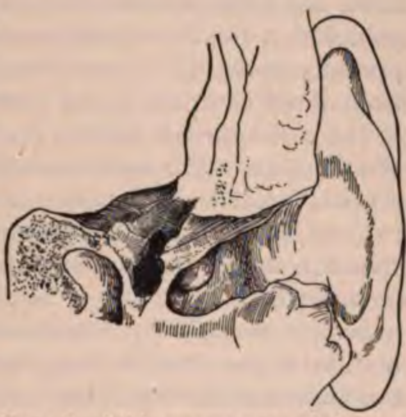


FIG. 78.—Otitis externa acuta of the deep portion of the meatus, indicative of inflammation of the mastoid. (Natural size.)

scribed external otitis and one due to an inflammation of the mastoid process (compare Figs. 77 and 78).

External manipulation will reveal considerable tenderness upon pressure in front of the tragus if the anterior wall is affected; indeed, as the entire fibro-cartilaginous portion of the canal is moved, to a certain extent, by any pressure in this region, this test in adults is of great importance in making the differential diagnosis between inflammatory affections of the meatus as distinguished from those of deeper parts—that is, of the middle ear or of the mastoid process. In the same way if the auricle be grasped firmly and moved in various directions, any inflammation in the canal will be evidenced by the pain which this manipulation causes. It is also well to exert pressure upon the walls of the canal from below upward and from above downward, and from behind forward successively. If the cartilaginous meatus is affected it will be scarcely possible not to elicit some tenderness, no matter where the abscess is located. The occurrence of œdema over the mastoid process may lead to the erroneous supposition that the osseous structures have become involved. This mistake need never be made if care is taken to test for the presence of tenderness over the mastoid process itself, without communicating any motion to the auricle in applying the pressure. To do this the fingers of the hand are rested lightly upon the side of the head, while the thumb is pressed firmly over the œdematous area, taking care that this pressure shall be exerted just behind the line of insertion of the auricle, and in a direction backward and inward rather than forward and inward. In this way the movable portion of the canal is in no way disturbed and the pressure is brought to bear directly upon the mastoid process. It will be found that where the inflammation is confined to the canal alone no tenderness is elicited by this manipulation, although the thumb may sink quite deeply into the œdematous tissues and leave its imprint there when removed. As soon, however, as the pressure is directed in the slightest degree forward, so as to move either the auricle or the fibro-cartilaginous canal, the patient gives evidence of intense suffering. Although simple in execution this point is of great value, especially in differential diagnosis. In the same manner a careful examination of the glandular infiltration, either behind the ear or below it, will usually enable one to recognize its nature in distinction from a mastoid periosteitis, or an extravasation of pus due to the spontaneous evacuation of the mastoid abscess beneath the sterno-mastoid muscle through the diagastric fossa. In some instances, however, it will be necessary to observe the condition for several days before an exact opinion can be arrived at.

A suppurative inflammation of the parotid gland may occasionally lead to error. This condition, from the local tenderness, the severe pain upon mastication, and the local tumefaction of the antero-inferior wall of the canal just within the orifice of the meatus, may sometimes be mistaken for a furuncle; especially is this the case when we remember that we frequently find the parotid enlarged secondarily as the result of the circumscribed external otitis located here. Practically such an error would be a matter of no significance, since the treatment would be the same. Upon evacuation of the abscess, either spontaneously or by incision, the quantity of pus discharged would readily show whether we had to deal with simple localized inflammation of the canal, or with a breaking down of the substance of the parotid, in which the pus had made its way to the surface in this situation.

Prognosis.—When uncomplicated, the affection ordinarily runs its course in from four to eight days, the symptoms being at their height about the third day. Care must be exercised in expressing an opinion upon this point, as the successive infection of other areas may prolong the affection considerably. The general health of the patient is a fact of great importance in considering how rapidly the termination of the disease may be expected, reinfection being much more apt to take place if the general condition is impaired. Personal cleanliness, precise attention in carrying out the local measures instituted for the relief of the condition, and the avoidance of any unnecessary handling of the part—all aid in bringing about a speedy termination. So far as danger to life is concerned, this is usually considered almost *nil*. It should be remembered, however, that in exceptional instances extension takes place both to the mastoid cells and to the middle ear, and that death has resulted from meningitis or sinus thrombosis. Occasionally dehiscences exist in the walls of the osseous meatus, rendering extension to the intracranial structures easy. It should also be remembered that after the contents of the abscess have been evacuated, either spontaneously or by incision, a denuded surface remains, through which infection may easily take place. The author has seen one instance of erysipelatous infection in this region, resulting in death.

Treatment.—If observed early, our first efforts should be directed to abort the attack, if possible, and thus prevent pus formation. With this end in view, the local abstraction of blood by means of the natural leech, or better, perhaps, by the wet cup, should be instituted at once. If the area in front of the tragus is tender the blood should be abstracted from this region. In an adult two ounces of blood may be taken away if the wet cup is used; if the natural leeches are preferred, two or three may be applied directly in front of the tragus. When the posterior or superior wall is the site of the inflammation the best results are obtained by abstracting blood from the mastoid region. Owing to the free intercommunication of blood vessels in this region it is usually wise to take away a greater quantity here than when the leeches are applied in front of the tragus. With reference to the relative value of the wet cup and the natural leech, it should be stated that the wet cup is to be decidedly preferred, except perhaps in the case of children under six or seven years of age, who may object less forcibly to the natural leech than any instrumental procedure. If the natural leech is used, the meatus should be occluded with cotton to prevent the animal from attaching itself within the canal, an accident which has occurred in several instances. The chief objection to natural leeches is that in many cases they are difficult to apply, and the precise quantity of blood taken away can not be estimated. The resulting hæmorrhage frequently continues for a considerable time after the leeches have been removed, and may be a source of annoyance both to the patient and his friends. Quite a number of instances have been reported in which erysipelas has followed their application, a fact which certainly constitutes a grave objection. The wet cup, on the contrary, affords us a means of taking away the exact amount of blood we deem desirable; it can be easily applied, and, if carefully done, its use is not attended by any more than trifling momentary pain. In very young children restraint will always be necessary whichever method is used, while adults almost invariably prefer to endure the momentary suffering which the artificial leech causes, rather than to subject themselves to the annoyance which the application of the natural leech entails. The instrumental abstraction of blood may be effected by the use of a device which consists of a glass tube closed at one end, while the margin of the open extremity is ground accurately to permit of its exact application to the integument. The interior of the tube is fitted with an air-tight piston, the rod of which is provided with a thread. The other extremity of the tube is provided with a cap through which the piston rod passes. Beyond the cap the piston rod is provided with a nut which traverses the thread upon the rod; by turning this nut the piston is made to travel the length of the tube.

If now the piston is lowered as much as possible, and the open extremity of the tube—previously smeared with a little vaseline—is applied closely to the skin, successive turns of the nut will exhaust the air from the tube and cause an intense congestion of the area which it covers, while the soft parts will bulge into the tube as the air above is rarefied, and the pressure of the air without will be sufficiently great to hold the apparatus in position. This process of dry cupping may of itself be sufficient in certain instances to relieve the symptoms; if, however, it is decided to abstract a certain quantity of blood, the cup should be left in position for a few minutes, after which it should be removed and the local congested area punctured in several places, either by means of a small, sharp knife or by a scarificator, shown in Fig. 79. In either case the process is not painful, as the turgescence of the parts is so great that but little sensitiveness remains. The cup should now be quickly reapplied, when a free flow of blood follows, and as much may be removed as seems desirable. The application of this instrument would at first seem painful, on account of the local tenderness in the immediate vicinity of the ear; it should be remembered, however, that local bloodletting is applicable only to the early stages of the disease, at which period this tenderness is not well marked.

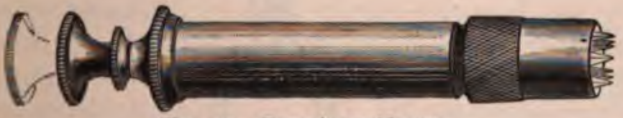


FIG. 79.—Bacon's scarificator.

In place of the instrument mentioned above, the author employs one in which the scarification is performed without the removal of the cup, while the ordinary ear syringe is used to exhaust the air. Fig. 80 shows the method of operation, and renders a detailed description superfluous. The instrument is so constructed as to be interchangeable with the tip of the ear syringe, and thus the necessity of carrying a cumbersome apparatus is avoided.

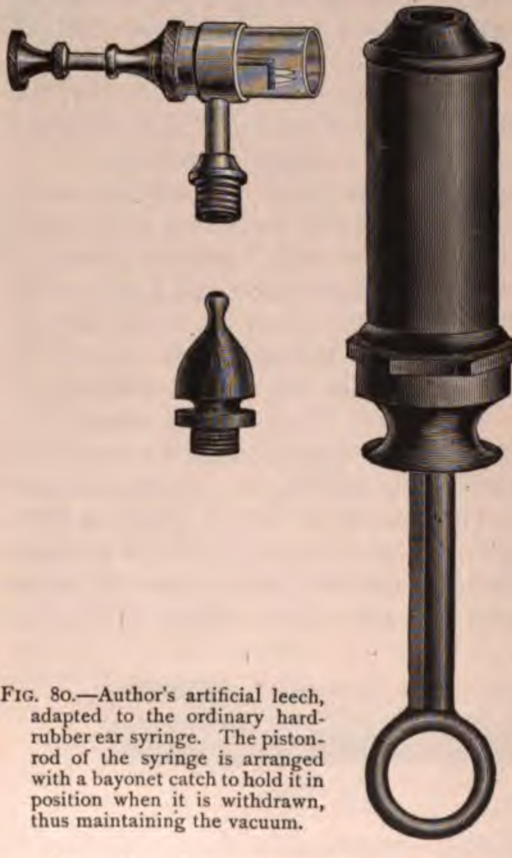


FIG. 80.—Author's artificial leech, adapted to the ordinary hard-rubber ear syringe. The piston-rod of the syringe is arranged with a bayonet catch to hold it in position when it is withdrawn, thus maintaining the vacuum.

As before stated, local bloodletting is of value in aborting the affection only in the very early stages. When the pain has lasted for thirty six or forty-eight hours before the patient is seen for the first time, this procedure will almost always be useless as a prophylactic measure, although it may temporarily relieve the pain; usually, however, it only adds to the discomfort which the patient is already suffering.

After the abstraction of a certain amount of blood in the very early stages, the local application of cold is of undoubted benefit, both for the relief of pain and for the purpose of aborting the attack. When the focus of inflammation is located upon the posterior wall of the canal, the application of cold may be made by means of the Leiter coil, shown in Fig. 81, the coil being so molded that it applies itself closely to the surface of the mastoid. The aural ice bag shown in Fig. 70 may also be employed for the same purpose. When the focus of inflammation is situated elsewhere, the coil behind the ear is of but little value, and, in order to be efficient, such an apparatus must be so arranged that a continuous stream of cold water is made to pass through a tube bent in the form of the letter U, and of such dimensions that it may be inserted into the auditory meatus. Theoretically, this is the ideal method of treatment; practically, it is of little value, for when the meatus is inflamed it is so tender that the presence of such an instrument causes considerable discomfort, and by its pressure aggravates the condition it is intended to relieve. Where the canal is large, however, the method may be tried.

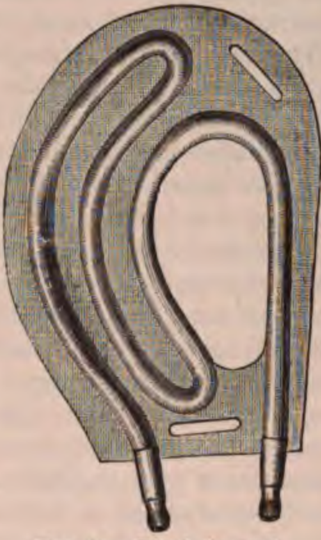


FIG. 81.—The Leiter coil.

The instillation of fluid preparations to relieve the pain seems to me to be a measure of practically no value whatever. A glance over the literature on the subject affords sufficient evidence of this, I think, on account of the large number of remedies which have been advocated. Thus we find recommended solutions of morphine, atropine, subacetate of lead, cocaine, menthol, oil of eucalyptus, dilute carbolic acid, veratrine, and, in fact, all the drugs of the pharmacopœia which have a real or imagined analgesic local action. It must be remembered that the absorption of any remedy from the unbroken skin takes place very slowly and produces, therefore, when applied to the cutis, almost no effect aside from that due to the evaporation of the liquid, with the consequent production of a certain amount of cold. The small amount of benefit to be derived from such applications is more than counterbalanced, in my opinion, by the sodden condition of the epidermis, which is produced by the retention of the liquid in the canal, making subsequent instrumental manipulations much more difficult, and masking to a very great degree the local appearance upon speculum examination.

No remedies should be employed locally unless the epidermis has already been exfoliated over a considerable surface, a condition with which we not unfrequently meet as the result of a previous chronic inflammation. When this condition is present, any of the before-mentioned drugs, either singly or in combination, may be beneficial. They are most conveniently used in the form of gelatin bougies, as advocated by Gruber* under the name of amygdale aurium. They consist essentially of small conical suppositories of gelatin, the drug being incorporated in their substance; the heat of the canal dissolves the gelatin, and the drug is thus brought directly into contact with the walls of the canal and even distributed over the inflamed surface. Previous to their insertion the canal should be thoroughly cleansed with a mild antiseptic solution, after which the suppository is inserted and the orifice of the meatus closed by a small pledget of cotton. This method is certainly preferable to the use of oleaginous preparations, and may to an extent relieve the pain if the superficial epidermis has desquamated. Care should be taken, when any of the stronger alkaloids are used in the external meatus, to determine positively that no perforation of the membrana tympani is present, since when this condition exists absorption may rapidly take place, either from the mucous membrane of the middle ear or by passage of the drug into the pharynx and subsequently into the stomach—an event which would be followed by constitutional effects. If morphine is to be used, it should be in the form of the alkaloid itself and not in the form of one of the salts, since the simple alkaloid is more readily absorbed endermically than any of its combinations. The cocaine ear bath may relieve the local pain somewhat, after the exfoliation of the superficial layer of the epidermis, and is principally indicated where the surgeon intends to incise the canal, in the course of a few hours, as the slow absorption may produce a certain amount of local anæsthesia.

While cocaine is of great value as a local anæsthetic, its local analgesic action is somewhat limited, and for this purpose we may more advantageously employ an alcoholic solution of menthol, dilute carbolic acid, creosote, oil of eucalyptus, thymol, oil of cloves, or some other aromatic oil. Of these remedies, menthol is perhaps the most efficacious in relieving the pain, which frequently is not confined to the ear, but may manifest itself as an intense neuralgia of the various branches of the fifth nerve. This use of menthol was first advised by Cholewa.*

---

* Lehrbuch der Ohrenheilkunde, Vienna, 1888, p. 292.

In addition to the relief of pain, its action as a germicide makes it particularly valuable, as it affords a means of combating the local infective process and of preventing the formation of other abscesses. It is best applied by inserting into the canal a long, narrow pledget of cotton previously saturated with a ten- to twenty-per-cent solution of the drug in albolene or olive oil. The relief obtained is often considerable. The only objection to its use is the fatty vehicle with which it is incorporated. As the menthol is antiseptic, this is unimportant. It may be avoided by using an alcoholic solution of menthol in the manner above described, or a five-per-cent solution may be dropped into the canal at intervals. If, for any reason, we prefer to use carbolic acid or creosote, the preparations should not contain more than ten per cent of the drug. Menthol will probably prove of more value than any of the other drugs mentioned above.

When a patient is observed at a stage too late for us to hope to abort the attack, the local abstraction of blood and the use of cold applications are worse than useless. The application of heat, however, is advantageous, as it relieves, to a very great degree, the intense suffering. Moist heat, however, is objectionable. The pernicious practice, so common, of applying a poultice to the ear, or of putting the heart of a roasted onion in the canal, the outer layers being applied to the outside to retain the heat, can not be too strongly condemned. Such procedures favor the development of successive crops of furuncles by causing a maceration of the epidermis lining the canal, and aid subsequent local infection. While heat, therefore, is one of our most valuable agents, it should be employed as dry heat. This may be secured by filling an ordinary flat bottle with hot water, wrapping it in several layers of flannel, and resting the head upon it. A more elegant form of application is the small Japanese pocket stove which is sold in the shops, which when once lighted affords us a means of applying dry heat locally, the small box being wrapped in flannel and either secured to the side of the head by means of a few turns of a bandage—its light weight rendering this practicable—or, after being enveloped in several layers of cloth, it may be placed upon the pillow and the patient may rest the ear upon it. The common hot-water bag, found in every household, can be used in this manner, but its employment requires that the patient shall be continually in the recumbent position, and this is sometimes undesirable. In addition to these measures, if we wish to apply heat more directly to the parts, I sometimes direct patients to cut off the finger-tips of an old kid glove and fill them with salt, the open extremity being closed either with a few stitches or by a few turns of linen thread. These small salt bags may be warmed upon a common tin plate on a stove, or over a gas flame or oil lamp, after which they may be inserted into the meatus. The salt retains its heat for a considerable period, especially if the external parts are kept warm by resting the head upon a hot-water bag or similar device.

---

* Therap. Monatsheft, 1889, No. 6.

Bearing in mind that the process is essentially one of local infection, our efforts should be directed, not only to the relief of the local condition, but to the prevention of the same infective process at other points in the canal. The canal should be thoroughly cleansed with a warm antiseptic solution by means of the syringe, using either carbolic acid, in the proportion of one to sixty, or the bichloride of mercury solution, about one to eight thousand. After syringing, which must be thoroughly but gently done, the ear is to be carefully dried with small pledgets of cotton rolled upon the cotton holder, the manipulation being conducted under ocular inspection by means of reflected light. The canal should next be filled with an alcoholic solution of boric acid of the strength of twenty grains to the ounce. As the sensibility of the canal varies considerably in different subjects, the instillation of alcohol may cause pain, and it is well to test the sensitiveness of the parts by touching the walls of the canal with a pledget of cotton previously moistened in the solution. If this causes pain the solution may be diluted with water, the quantity of water being rapidly diminished at each successive application as the sensitiveness of the parts becomes less. The instillation of this alcoholic solution should be repeated at least four times during the twenty-four hours, and it is often advantageous to repeat it still more frequently. The syringing of the canal not only removes any discharge, together with exfoliated epithelial cells, but often relieves the pain to a very marked degree. Although frequent syringing of the canal is not advocated by the majority of writers, it has been my custom, especially in dispensary practice, to direct the patient to cleanse the ear in this manner several times daily, after which the alcoholic solution may be instilled in the manner already described. If the case is seen twice daily by the surgeon the patient need not use the syringe at home, but may instill the boric-acid solution without previous cleansing of the canal. It is seldom necessary for the surgeon to see the case as frequently as this, however, and equally good results are obtained if the canal is syringed by the patient twice or three times daily, the alcoholic solution being used after each irrigation. The surgeon should, if possible, see the patient daily for the first few days.

While all of these methods possess a certain amount of value the measure which stands pre-eminent in the treatment of this affection is that of early incision. To this, I think, we should always resort if our efforts to abort the attack by local bloodletting are not successful, or if the patient is seen at so late a stage as to preclude the possibility of it. It is not advisable to wait until the formation of pus has taken place, or even until local tumefaction is so extensive as to be easily recognized by ocular inspection. The process is most frequently deeply situated at first, and becomes superficial only a short time before spontaneous rupture occurs. Testing the walls of the canal by means of a cotton-tipped probe in the manner already described will enable the surgeon to recognize the affected area as certainly as if local tumefaction were present. The point of greatest tenderness should be incised deeply and freely with a sharp, short, strong, curved bistoury, the incision being carried through the perichondrium or periosteum, as the case may be. It must be of sufficient length to relieve all tension. This procedure is excessively painful—in fact, I know of no measure employed in surgery which causes such exquisite suffering as the early incision of a localized inflammatory area in the canal, but the relief afforded fully justifies the surgeon in inflicting this momentary pain. The beneficial results obtained depend not only upon the relief of tension, but also upon the very free bleeding which follows, this latter result being also beneficial in reducing the liability to the development of a similar condition in some other part of the canal. General anæsthesia is seldom required, as when a properly formed instrument is used it is only necessary to make the initial puncture under ocular inspection, the surgeon being able to control the extent and direction of the incision by his tactile sense quite as well as by the sense of sight. The operation can be rendered painless by the administration of nitrous oxide, and as this anæsthetic causes no subsequent constitutional disturbance, it may be used with advantage. Local anæsthesia is of no value in these cases.

After the focus of inflammation has been incised the rules already given concerning cleansing of the parts should be carried out, with the exception that any alcoholic solution applied to the canal must be considerably reduced in strength, as otherwise severe pain would be produced by its instillation. The cleansing may be effected either by the ordinary ear syringe (Fig. 82), the small soft-rubber-ball syringe, or, if considerable pain persists, continuous irrigation of the canal may be employed. This may be carried out by using the ordinary fountain syringe. A warm antiseptic solution, either of bichloride of mercury, one to eight thousand, or of boric acid, in the proportion of twenty grains to the ounce, may be allowed to flow over the parts continuously for a period of ten to twenty minutes. If this is done immediately after incision, the attendant pain quickly disappears, while the warmth of the application favors free hæmorrhage from the wound. This local depletion both relieves the pain and renders the reparative process more rapid. After free incision the relief is usually immediate, and in the course of twenty-four hours the parts assume more nearly their normal contour. The discharge, however, continues for a few days, during which time the infection of adjacent areas is very liable to take place unless attention is paid to the systematic cleansing of the parts, as above advised. Ordinarily the abscess cavity becomes completely obliterated and the canal wall resumes a perfectly smooth and normal outline; exceptionally, where the process has been very deep seated and a considerable area has been involved, exuberant granulations spring up about the margins of the opening. If very large, these may be removed by means of the cold snare or sharp curette. Usually, however, they are so small as to require simple cauterization

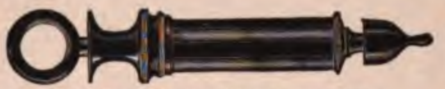


FIG. 82.—Hard-rubber ear syringe.

by a chemical agent. We may employ for this purpose either chromic acid or nitrate of silver, the former to be applied in substance, a minute bit of the acid being fused upon the tip of a metal probe and applied lightly to the efflorescent tissue, after this has been previously dried by a pledget of cotton; any excess of acid must be immediately wiped away by means of a cotton-tipped probe, as otherwise the agent quickly spreads over the walls of the canal, and severe diffuse inflammation may result. The nitrate of silver may be used in the same manner, or may be applied as an aqueous solution of from two hundred and forty to four hundred and eighty grains to the ounce. I prefer the chromic acid, as in my hands, at least, it has never caused any reaction, while occasionally the silver preparations excite a severe secondary inflammation of the walls of the canal. If the destructive process has involved not only the integument, but also the underlying cartilaginous or bony structures, rather extensive necrosis may take place, retarding the healing process to a marked degree. In such an event it is well thoroughly to curette the cavity, removing all diseased tissue by means of the sharp spoon, after which rapid healing ensues.

In addition to the local measures here advocated, the condition of the general health should always be borne in mind as furnishing a prominent predisposing cause of local disease. Especial attention should be paid to the gastro-intestinal canal; constipation, if present, should be relieved, or disorders of the digestion corrected by the administration of alkalies or acids, as seem indicated. One of the most common causes underlying this affection is simple anæmia. This is best combated by the use of some of the ferruginous preparations. Probably no specific exists upon which we can depend to produce any marked effect upon the progress of the local inflammation. Sulphide of calcium, so much used in general furunculosis, has been frequently advocated, and for a considerable period I administered it regularly in every case, but was unable to perceive any beneficial results from its action. If its use seems indicated in any instance, it is best given in the form of a pill containing one sixth of a grain of the drug. One pill is to be taken every hour for six doses, after which the interval may be reduced to every two hours. After this medication has been continued for twenty-four or thirty-six hours the doses may be repeated less frequently, say at intervals of every four or six hours. It will generally be found, however, to exert very little action upon the disease. The internal administration of drugs intended to relieve the intense suffering of the patient is always advisable in the very early stages. There can be no question that the relief of pain for a period of six or eight hours, when the process is in its incipiency, does exert a certain permanent beneficial action, the tendency being to increase the resisting power of the patient. By relieving the pain or rendering it more bearable, our efforts toward aborting the attack will be more successful. It is to be borne in mind also that the pain will continue for only a comparatively short period of time; hence, the administration of opiates is not open to the objection that the patient is liable to acquire the opium habit. In the later stages of the affection analgesics are contraindicated, as they may mask mastoid involvement.

Chronic Circumscribed External Otitis.

But few words need be said in consideration of a circumscribed local inflammation of long duration. It is usually symptomatic of some affection of the deeper-seated structures, either cartilaginous or bony. In the former instance it results from a very severe form of the disease just described, while in the latter case it is usually indicative of some pathological process within the mastoid cells, and is situated in the bony canal. The condition which clinically may be considered as belonging to this group, although from a pathological point of view it should be placed elsewhere, is that met with when suppuration takes place in the sebaceous cyst located in the meatus. These neoplasms usually occur on the anterior or inferior walls of the canal, near the orifice, and either discharge spontaneously, or, if their contents have been evacuated by surgical means, persist for a long period, the lining membrane being of such a nature that adhesive inflammation with resultant obliteration of the sac is impossible. The cavity refills slowly after each evacuation of its contents, and the symptoms of obstruction of the meatus due to the presence of the tumor, together with intermittent discharge at somewhat irregular intervals, are repeated for an indefinite period. Under these circumstances simple incision does no good, and will afford but temporary relief. The lining membrane of the sac must either be dissected out entire, or, if this is impossible on account of the location of the tumor, it must be completely destroyed by the curette, after which recovery is prompt.

We shall consider circumscribed inflammation of the bony meatus dependent upon mastoid inflammation in the section devoted to mastoid disease.

CHAPTER XII.

DIFFUSE EXTERNAL OTITIS.

THIS affection may occur in either acute or chronic form, and, as its name implies, constitutes an inflammation of the external auditory meatus, in which the local condition, instead of being confined to a small area, involves either the entire canal or a very large portion of it, the line of demarcation between the normal and affected areas not being clearly marked, but merging gradually into each other. Since the acute form of the disease is frequently dependent for its cause upon a previously existing chronic inflammatory process, we will consider, first, the chronic, and afterward the acute affection.

CHRONIC DIFFUSE EXTERNAL OTITIS.

This general term applies to the superficial extent of the lesion rather than to its severity, and comprises every degree of chronic inflammatory condition of a diffuse character, from those cases in which only the superficial layer of the epidermis is involved to instances where not only the cutaneous lining is affected through its entire depth, but the cartilaginous and bony framework as well.

Ætiology.—This disease is less dependent upon constitutional conditions than is the circumscribed form of inflammation. Traumatism plays a very prominent part in its production. The impression so common among many that the external auditory meatus must be subjected to thorough cleansing by means of the corner of the towel wound up so as to permit its entrance into the lumen of the canal, or by the introduction of various ear sponges, ear spoons, etc., furnishes one of the most fruitful sources of mild but persistent inflammatory conditions of diffuse character. Wounds of the canal walls, either inflicted by mechanical violence or resulting from the bites of insects which find their way into the meatus, are also among the most frequent causes of the disease. The application of oleaginous substances to the walls of the canal, for the relief of pain in the ear, or sometimes for toothache, is practiced not uncommonly among the laity, and furnishes a source of irritation to the lining of the canal. Foreign bodies, introduced by mistake or design, by their presence alone frequently cause a condition of diffuse inflammation. The most common cause of the condition is some affection of the middle ear attended by a purulent discharge. When the walls of the canal are continually bathed with such a secretion, they soon lose the superficial layer of epithelium through the combined action of warmth and moisture. Thus a denuded surface is left, through which infection may take place. This is more commonly met with among that class of individuals who pay little attention to habits of cleanliness, and hence make no effort to keep the passage free from secretion by frequent irrigation. Among the more uncommon causes is the development of vegetable parasites within the canal. These minute organisms attach themselves firmly to the walls of the meatus, and grow for an indefinite period. As their growth continues they become firmly imbedded in the deeper layers of the integument, and their removal results in the loss of the superficial epithelium and an exposure of the underlying cells. It is probable that the condition never engrafts itself upon a perfectly healthy integument—that is, one in which the horny layer of the skin is unbroken throughout the entire extent of the canal. If, however, the integument at any place is abraded, the moist surface forms an excellent soil for the development of a parasite. Having once taken root, the fungus may increase indefinitely by subsequent growth. The continued presence of fungi produces an effect similar to that of a foreign body—that is, it causes an inflammation of the lining of the canal.

Constitutional causes, we have said, are not important factors in the production of this disease; we make one exception, however, in the case of eczema of the canal, which, like eczema in other parts of the body, is an evidence of some diathetic condition.

Pathology.—An affection dependent upon such a variety of causes must necessarily present physical characteristics differing greatly. Under the milder types we would include those cases of augmented glandular activity resulting in an increase in amount of the secretion from the sebaceous follicles with which the skin is supplied. When the inflammation involves the inter-glandular tissue, as in eczema of the canal, there is a certain amount of infiltration of the deeper layers of the cutis, causing the superficial epithelium to be cast off more rapidly than under normal conditions. According to the degree of the infiltration of the integument, a greater or less amount of serum exudes, which, washing away the desquamated cells when the transudation is profuse, leaves a red, smooth, glistening surface; or when less fluid is poured out it dries upon the walls of the meatus, forming with the desquamated epithelial cells yellowish crusts, which adhere to the canal walls and partially or completely occlude the passage. If the process is allowed to progress, actual hypertrophic changes take place in the basement membrane and the meatus is gradually converted into a tube of very small calibre, the opposing walls lying nearly in contact. An inflammation of the external canal occurring in the bony portion, where the cutaneous lining is very thin, and where it constitutes the periosteum, may extend to the osseous tissues and produce the symptoms which characterize an inflammation of the mastoid process, or, where the Rivinian segment is imperfectly closed, it may pass by continuity of structure into the tympanum and excite an inflammation within this cavity.

When the inflammation of the canal is due to the presence of a foreign body, or follows a wound of the canal, a circumscribed acute inflammation, or the development within the meatus of a vegetable parasite, the changes which take place vary in intensity, but are of the same character as those above described. The superficial epithelium is thrown off rapidly, the deeper layers of the cutis are infiltrated with round cells and become thickened, and tissue hypertrophy finally results. In the more severe cases tissue necrosis may take place or by extension the underlying bone may become involved.

In some cases we find the activity of the inflammatory process directed especially toward a rapid proliferation of the superficial epithelial layer of the integument. The flat pavement cells are thrown off rapidly, and, aggregating in the meatus, form a compact mass, which completely fills the deeper portion of the canal. From the increase in the blood supply incident upon inflammation a small amount of serum is transuded; the fluid moistens the compact epithelial mass and causes it to increase in volume. In this way great pressure is exerted upon the surrounding bony walls, which may be absorbed or become necrotic, or the pressure may be so gradual as to interfere but little with the nutrition of the parts, and result in a dilatation of the deeper portion of the meatus by crowding backward that part of the wall which separates the canal from the mastoid cells, so as to obliterate the pneumatic spaces of this portion of the temporal bone.

In the above consideration we have followed the extension of the process from the canal inward toward the deeper portions of the conducting channel. But a diffuse external otitis may be of a consecutive nature; that is, the deeper parts may be involved first, and by extension produce an inflammation of the walls of the meatus. This is particularly true where the deep osseous canal is the site affected. The upper and posterior portions of the canal at this point form the inferior or anterior walls of the mastoid process; hence, an inflammation involving the mastoid antrum and the smaller pneumatic spaces frequently produces an inflammation of the canal in this region diffuse in character, the process being as much a mastoid periostitis as if the outer wall of the mastoid, lying immediately behind the ear, were the part affected.

While it lies beyond the province of this work to give any detailed account of the microscopic appearances of the various forms of vegetable parasites found in the meatus, certain characteristics which are common to all of these should be understood, in order that a diagnosis may be made between the purely epithelial or desquamative type of inflammation and that form dependent upon the presence of fungi. These fungi present under the microscope long fibres or hyphæ of a double contour, either completely transparent or slightly granular. These fibres divide into branches dichotomously (Fig. 83), which terminate in a globular head or fruit-sac (sporangium) (Fig. 84)

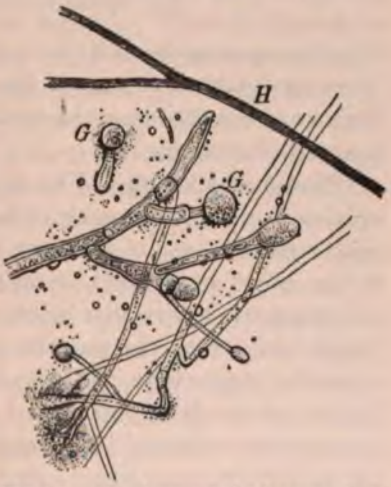


FIG. 83.—Development of a fungus. *G, G,* Sporangia; *H,* Hyphæ. (Gruber.)

filled with minute spherical spores. Examination of the fruit-sac at a certain stage of development will show thin filaments radiating from a central stalk toward the periphery through the mass of minute spores. These fresh filaments in turn develop sporangia, and the process repeats itself indefinitely. The recognition, then, of the mycelial filaments or of the fruit-heads containing the spores establishes the diagnosis of parasitic inflammation.

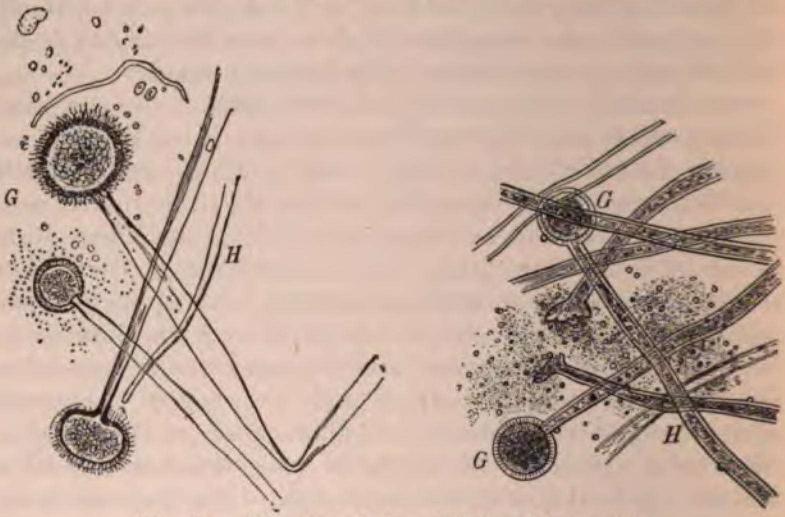


FIG. 84.—Microscopical characteristics of otomycosis. *G*, *G*, Sporangia ; *H*, Hyphæ. (Gruber.)

Symptomatology.—The symptoms differ in severity in accordance with the degree of intensity of the local process. In mild cases a sense of constant irritation or itching in the canal is the most prominent symptom, the patient continually attempting to relieve this by the insertion of the tip of the little finger as far into the meatus as possible ; this, naturally, only tends to aggravate the condition it is intended to relieve. When, either from increased glandular activity, as in seborrhœa, or from actual inflammation, as in eczema or otomycosis, the canal becomes to an extent occluded, either by the scale-like sebaceous crusts, or by aggregations of epithelium resulting from eczema, or by masses of vegetable fungi, certain symptoms dependent upon this occlusion manifest themselves. These may consist in an impairment of the hearing, varying in degree according to the extent of obstruction, or there may be tinnitus caused by the congestion which the presence of the foreign substance induces, or certain reflex symptoms may manifest themselves, such as severe pain spreading over the distribution of the fifth nerve, headache, either general or local, and, rarely, disturbances of a graver nature, disproportionate in severity to the local condition. Thus, instances of epileptiform attacks have been traced to inflammatory conditions within the canal, while symptoms referable to the opposite ear may also be produced by a chronic inflammation of the external auditory meatus of one side. A symptom frequently complained of is that of autophony, the patient's own voice seeming to come from the affected side. This occurs only when the lumen of the canal is considerably narrowed.

Cough is a not infrequent symptom of the affection, and may, in fact, be the first to attract the attention of the patient and cause him to seek advice. In all cases of cough, even although apparently explainable upon other causes, it is always well to examine the external auditory meatus, as an accumulation of any foreign material, resulting either from desquamation of the epithelial lining of the canal or from the aggregation of a mass of aspergillus, may cause a reflex cough. As the affection increases in severity a discharge may make its appearance at the orifice of the meatus. This discharge is ordinarily scanty, and, in fact, may be so small in amount as to appear in the form of crusts about the margin of the meatus, the fluid elements having been evaporated. When more profuse the discharge is watery in character, but is never large in amount. In the milder cases, due to an inflammation of the glandular structures alone, the discharge appears in the form of minute scales, which are oily to the touch, on account of the fatty matters which they contain. Occasionally, in cases of very long duration, the inflammation, instead of producing a fluid discharge, causes a proliferation of the epithelial lining of the meatus. The superficial epithelial cells are rapidly cast off, and, aggregating into masses, remain in the canal for a long period. These masses of desquamated epithelium absorb the watery secretion which the thickened cutaneous lining of the canal exudes, and as the process continues increase steadily in size. From the fact of their slow increase in volume these epithelial plugs exert a great amount of pressure upon the walls of the canal, leading, in some cases, to a dilatation of the bony canal, either by causing an absorption of the osseous tissue or by crowding the thin bony wall upward and outward toward the mastoid cells, which become correspondingly diminished in size. At the same time the osseous tissue undergoes certain structural changes as the result of this mechanical irritation, so that, instead of presenting the ordinary cancellous appearance, it becomes converted into a hard, ivory-like substance of uniform density. This change may extend throughout the entire mastoid, all the air spaces being obliterated with the exception of the antrum, or, if the pressure is still greater, the bony walls of the canal may be absorbed entirely, and the upper part of the tympanic cavity and the mastoid cells may thus be continuous with the external auditory meatus.

Glandular enlargement is not uncommon as the result of chronic inflammation of the external meatus, and when the glands just below the lobule are affected a mistake in diagnosis is possible, the case presenting many of the characteristics of a perforation through the tip of the mastoid process.

We have spoken of dilatation of the bony canal as the result of a desquamative inflammation with the consequent absorption or displacement of the bony walls. The opposite effect may be produced, however, if, instead of causing a desquamation of the superficial epithelium, the deeper layers of the integument are the seat of inflammation; in these cases the lumen of the canal may become very narrow—in fact, it may be so diminished in size as to admit only the smallest probe. This diminution in calibre is due to an actual hypertrophic osteitis rather than to any thickening in the soft parts. This change frequently takes place in the cases of diffuse external otitis which accompany a chronic suppurative process within the middle ear. Instead of narrowing the calibre of the canal uniformly, certain limited areas within the canal may be affected, producing what is known as an exostosis or a circumscribed bony growth, which projects to a greater or less extent into the passage. These growths are most frequently situated near the drum membrane, and, according to their size, interfere with the function of audition.

Diagnosis.—The diagnosis of chronic diffuse external otitis will be determined both by external manipulation and by examination by means of the speculum. We have to distinguish by palpation between an affection confined to the canal and one involving the mastoid process, as the superior and a portion of the posterior walls of the meatus form the anterior and inferior wall of the mastoid process. It would seem that this differentiation is rather superfluous, but the author intends here to separate those cases in which the affection of the canal is the prominent feature, the mastoid being involved to so slight an extent as to give rise to no symptoms and to require the employment of no special measures, from those cases in which the affection of the canal is merely symptomatic of a deep-seated inflammation within the mastoid, in which treatment must be directed to the mastoid inflammation as the primary disease. When the affection is confined to the canal, pressure behind the ear, directed backward and inward, will fail to elicit tenderness; if the pressure is exerted in such a way as to move the fibro-cartilaginous meatus, very marked tenderness will be elicited. In the same way pressure from below, above, or in front of the canal will cause more pain than if made directly over the mastoid process. The appearance presented upon inspection by reflected light will vary according to the cause and character of the affection, as well as with its intensity. In the milder cases, under which we include seborrhœa, eczema, and a chronic otitis externa diffusa caused by an aspergillus, inspection will show that the walls of the canal are covered either partially or completely with some foreign substance. In seborrhœa this will be confined almost entirely to the cartilaginous meatus, and the deposit will appear to be made up of small, thin, yellowish crusts which are easily detached and upon compression between the finger and thumb have an oily feel. The surface from which these small scales are detached is somewhat reddened, but not moist. In eczema the crusts are larger, adhere more closely to the walls of the meatus, and are evidently made up of desquamated cells which have been moistened with serum and have become agglutinated into a mass. This collection of cast-off cells has subsequently dried into thick, irregular, yellowish-brown crusts. Here the affection extends from just within the orifice of the meatus to the drum membrane itself; the crusts are detached with some difficulty, their former location presenting as a red, moist area, which, upon being dried with a cotton pledget, quickly becomes coated with a thin serous transudate. Inspection and tactile manipulation by means of the probe demonstrate an evident thickening of the deeper layers of the cutis of the canal.

In the milder forms of aspergillus the canal walls are covered, sometimes throughout their entire extent, at other times only here and there, by a whitish or yellowish-white deposit, which seems to be closely adherent to the underlying structures (Fig. 85). The entire lumen of the canal may appear somewhat narrow. Upon using the cotton holder to wipe out the meatus, in order that inspection may be more exact, the parts may be found to be moist, the instrument removing from the walls of the canal, in addition to the moisture which it has absorbed, thin, moist flakes or scales, usually of a whitish color, the surface from which they were removed appearing denuded. Upon attempting thoroughly to clear the canal it will often be found possible to detach relatively large thin sheets of this deposit, of a white or a dirty yellowish-brown color, having the consistency of moistened paper. In this way a complete cast of the canal from the very orifice of the meatus may be obtained. If the process has spread to the drum membrane the cast will form a blind sac, the closed extremity bearing the imprint of the various landmarks of the membrana tympani. This deposit is due to the growth of low vegetable organisms upon the walls of the meatus. The special species of plant life can only be determined by microscopic investigation; the varieties met with are extremely numerous, but as the treatment of the different forms does not vary essentially it is unimportant to discuss the condition at length in a treatise devoted particularly to clinical otology. Certain macroscopic features, however, enable us to make a reasonably accurate diagnosis as to the particular variety of plant present in a given case. A white deposit usually consists of the aspergillus glaucus. Another variety is the aspergillus flavus, the microscopic features of which are shown in Fig. 86, while more rarely we find the walls of the canal and the surfaces of the membrane covered with irregular black spots, a little smaller than the head of a pin, which are the

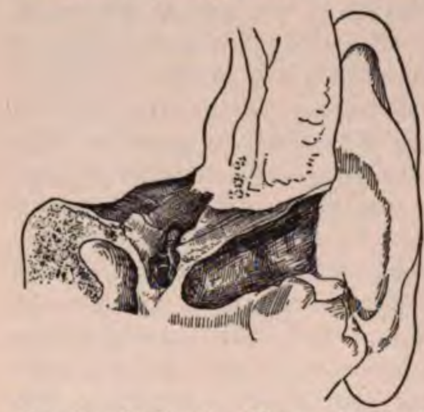


FIG. 85.—Otomycosis. The canal is lined with a thin deposit which covers the walls and the surface of the membrana tympani. The punctate areas on the membrana are caused by the increased growth of the fungus in these situations. (Natural size.)

sporangia of the aspergillus niger. The growth of this latter is seldom as extensive as that of the other two varieties. A microscopic examination alone will enable us to distinguish with certainty between otomycosis and the milder forms of desquamative inflammation involving the canal. The greater consistency of the epithelial plug and the imbricated arrangement of the scales usually give the observer a hint as to the nature of the condition present. It is probable that in no case do these low forms of vegetable life take root upon a perfectly healthy cutaneous surface; it is necessary that the epithelium should be wanting over a small area at least, in order that the plant may develop. Hence it is, that parasitic inflammation of the meatus is usually coexistent with some condition of the external canal or of the middle ear characterized by the presence of moisture. The epithelium of the canal is thus softened and thrown off, leaving a surface which forms an excellent site for the development of a low form of plant life, the growth being stimulated at the same time by the presence of moisture. The mere presence of aspergillus spores in any aggregation of foreign matter which may be removed from the meatus does not warrant a diagnosis of parasitic inflammation of the canal, since it is usual to find them in ceruminous masses, or upon any foreign body which has remained in the canal for a considerable length of time. It is only when they constitute the bulk of the mass that this constitutes a lesion proper.

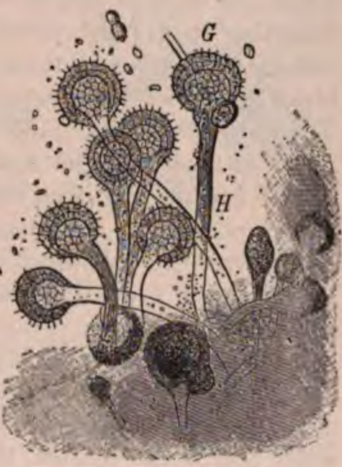


FIG. 86.—Aspergillus flavus. *G*, Sporangium; *H*, Hypha. (Gruber.)

The diagnosis of the desquamative form of inflammation will be based upon the presence in the deep meatus, of a compact mass, whitish in color, which, although easily penetrated by the probe or curette, is removed with considerable difficulty. The walls of the canal are ordinarily moist and present a sodden appearance, the superficial epithelium being easily wiped off by means of the cotton pledget, which, upon investigation, is found to be covered with thin white flakes of irregular size and shape. If the probe is immersed in water these are seen to spread out and float upon the surface, but are not dissolved by the fluid; they are really the epidermal cells lining the canal, which have been thrown off by the inflammatory process. The obstructing mass is an aggregation of these cells, and, though easily penetrated by any instrument, which may remove a considerable quantity each time it is inserted, is very difficult to remove completely. Even when the fundus seems entirely clear we often find, in attempting to dry the parts perfectly, that the cotton pledget brings away more of these white scales, so that the complete clearing out of the meatus is a matter of no small difficulty. The entire epithelial plug presents an appearance not unlike a wad of unsized paper that has been moistened in water, and, in fact, is often mistaken for a foreign body of this kind, which has found its way into the canal.

Where the inflammation is of what may be called the symptomatic type—that is, merely an indication of a deeper-seated inflammatory process within the mastoid—we usually find that the superior and posterior walls of the canal close to the membrana tympani are most involved. The canal lumen at its deepest part is narrowed by an apparent sinking of the walls, and at the fundus, instead of a well-defined line of demarcation between the drum membrane and canal walls, it appears as if the superior and inferior walls were separated only by a narrow slit, through which a small area of the membrane is seen. The chief point of diagnostic importance is the difference between this condition and that seen in circumscribed otitis externa. In this latter form, after the speculum has been introduced into the canal, the membrana tympani is distinctly seen, and appears normal in extent as the obstruction lies near the orifice of the meatus. In the disease under consideration the introduction of the speculum is easy, but the canal becomes more obstructed as we approach the fundus, owing to the fact that the disease is a periostitis of the deeper part of the canal (Fig. 78). It is of extreme importance, especially in children, to recognize this condition early, as it is one of the best indications that a previously existing middle-ear inflammation has involved the deeper structures, or that an accumulation of pus in the tympanum has passed out through the Rivinian fissure along the superior and posterior aspects of the meatus (Fig. 87). In either case the condition is one which requires prompt treatment in order that serious consequences may be averted. The appearance presented by a chronic diffuse otitis, resulting in either uniform narrowing of the meatus or isolated bony deposits or exostoses, offers no difficulties in diagnosis. When the latter condition is present, care need only be taken to so cleanse the parts that the observer may be certain that the localized encroachment upon the lumen of the canal is beneath the integument instead of superficial to it. It would seem almost impossible for this mistake to be made, but masses of hardened cerumen occasionally present the appearance of an exostosis, the surface of which is covered by a thin layer of cerumen. By means of the curette any foreign substance is easily removed from the canal wall, and the true condition becomes apparent at once.

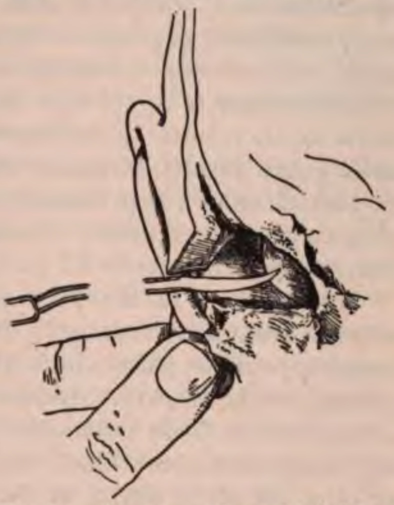


FIG. 87.—Appearance observed in infancy when fluid from the tympanum escapes through the Rivinian fissure. (Natural size.)

Prognosis.—The course pursued by the disease we are here considering is as varied as the causes which underlie it. The simpler varieties are unattended by any grave results, although somewhat obstinate to relieve. Where the deeper parts are involved, where the disease is of long standing, or where the condition is symptomatic, the prognosis is frequently grave. Important regions may suffer secondarily, by extension directly from the canal, or the condition within the meatus may, if unchecked, spread to the middle ear and result in any of the sequelæ of a severe inflammation within the tympanum. Where the disease is secondary to an intratympanic affection the gravity of the prognosis depends more upon the condition of the middle ear than upon the changes within the canal. As regards the impairment of function, the power of audition may suffer either from the narrowing of the meatus throughout its entire extent or by the development of circumscribed bony deposits. In some instances the chronic congestion of the deeper structures caused by a chronic inflammatory process within the meatus, may lead to functional impairment. In the desquamative form of inflammation the pressure exerted by a mass of epithelium may produce fatal results by absorption of the bony walls and exposure of the cranial contents. This may occur without any symptoms of middle-ear inflammation, or the membrana tympani may be destroyed and a suppurative otitis media result. Sometimes the mass, while not leading to such grave results, seriously impairs the function of the ear by chronic adhesive processes within the tympanum from the long-continued pressure. In other cases the pressure causes labyrinthine changes.

Treatment.—In the mild cases of chronic diffuse otitis externa treatment is largely directed to the relief of the distressing pruritus from which the patient suffers. The crusts arising either from involvement of the sebaceous glands in seborrhœa or from cutaneous infiltration in eczema should be removed by some bland oily application, such as vaseline or olive oil, after which, in the glandular variety of the disease, it will be sufficient to apply once each day a slightly stimulating ointment, such as the unguent. hydrarg. ammoniat., diluted with ten parts of vaseline or cold cream, or the unguent. hydrarg. oxidi flavi may be employed in about the same strength. In eczema the various measures detailed under eczema of the auricle will be found valuable. It is important, in order that the treatment may be efficacious, that the patient should refrain from scratching the ears, as this increases the local inflammation. For this purpose we may add either cocaine or morphine to the above ointments. It is well for these patients on retiring to insert into the ear a pledget of cotton smeared with such an ointment, as they frequently injure the parts during sleep. The use of water in any inflammatory condition of the canal attended with infiltration of the integument is to be absolutely forbidden, as it tends to increase its activity.

In the parasitic variety the fungus should be removed as completely as possible by means of the curette, forceps and cotton pledget, great care being taken to avoid abrading the epidermis of the canal. In these cases the walls of the meatus will be found very sensitive, and the complete removal of the parasite will be difficult. The occasional application of a ten per cent. solution of cocaine during the operation will afford considerable relief and will facilitate the operation. It is not well to prolong unduly our efforts at removal or to inflict severe pain. After as much as possible has been removed a solution of bichloride of mercury, one to eight thousand, in fifty per cent alcohol, or a saturated alcoholic solution of boracic acid, or a two-per-cent alcoholic solution of salicylic acid, as Siebenmann* recommends, should be applied to the parts by means of the cotton pledget.

It is sometimes well to employ a powder instead of the above solutions. The walls of the canal may be lightly dusted with boracic acid or a mixture of boracic acid and salicylic acid in the proportion of twenty to one. In this way we avoid the presence of moisture, a condition which we know favors the growth of the fungus. It is well to see the patient daily at first, and at each sitting to remove as much of the deposit as possible. When the canal seems free the antiseptic solution should be placed in the hands of the patient, and he should be directed to instill ten or twelve drops of either preparation into the canal twice or three times daily. By this means any new growth is prevented and a complete cure effected. Remembering that an otomycosis is often dependent upon a suppurative inflammation of the middle ear, it is scarcely necessary to state that this affection, if present, must be treated properly in order to prevent the recurrence of the condition.

Prophylactic measures against development of organisms within the meatus should be taken in all cases of aural disease which come under the observation of the surgeon. A common cause of the milder varieties of this affection depends upon a habit so common among the laity of instilling oily solutions into the ear for the relief of pain. Not only should this be forbidden, but the surgeon should be particularly careful in cases where it is necessary to use oily substances within the meatus that none of the fatty material remains in the canal when the patient is discharged. To be certain of this it is advisable upon dismissing the patient to wipe the canal thoroughly with a cotton pledget moistened in alcohol.

In the desquamative form, the first indication is to remove the mass of epithelium filling the canal. This is by no means simple where the disease has persisted for a long time, especially as attention is frequently drawn to the condition for the first time by an acute inflammation of the parts, resulting in so much swelling that the calibre of the canal is greatly reduced.

---

* Arch. of Otol., vol. xviii, p. 235.

Our first efforts at removal should be by the use of a warm antiseptic solution injected into the ear by means of the syringe. This will usually bring away the superficial portion of the mass, and occasionally all of it. Frequently, however, the deeper portion of the canal remains obstructed, and it will be necessary to use the blunt curette in order completely to remove the collection. When the canal is swollen and tender, as frequently occurs from an acute exacerbation, the manipulation is extremely difficult, and sometimes a general anæsthetic is necessary. In using the curette, we should first attempt to separate the mass from the canal along one wall, and afterward break it up by inserting the instrument between it and the canal wall and removing small portions successively until a narrow channel has been made between the canal wall and the foreign body. By directing the stream of water from the syringe toward this channel, the entire mass may usually be brought away, although it may be necessary to remove the entire collection piecemeal with the curette. If it is impossible to insert the curette between the epithelial aggregation and the canal wall at any point, owing to the tenderness of the meatus, our efforts are sometimes more successful if a passage is tunneled directly through the centre of the plug, after which, by carrying the curette into this channel and then pressing it in toward the opposite wall of the canal, the portion included between the instrument and the wall may be removed; the process must be repeated until the meatus is perfectly clear.

Where the condition has remained unrecognized for a long time, the bony meatus close to the drum membrane may be very much dilated, and the foreign body attain such dimensions as to render its removal from the meatus in its entirety impossible. At the same time the deep meatus has been so dilated that the manipulation of any instrument, such as the curette or a spoon, is very much restricted. These epithelial masses may invade the cells of the mastoid process through the absorption or necrosis of the bony walls from pressure. It occasionally becomes necessary to open the mastoid in order completely to eradicate the disease. Such cases have been reported, but an element of doubt always remains as to whether they were not cases of cholesteatoma originating within the tympanum and invading the canal secondarily.

After the canal has been thoroughly cleared, our efforts should next be directed toward putting the epidermis in normal condition. Here powders are of special benefit, as they relieve the sodden condition of the parts more quickly than do fluid preparations. For this purpose boracic acid may be dusted over the walls of the canal, or a mixture of boracic acid and iodoform, or iodol, if the odor of iodoform is objectionable. Quite recently the introduction of dermatol into surgery has given us a drug particularly adapted to these cases. These measures should not be trusted to the hands of the patient, but should be carried out by the surgeon—at first daily, the interval being increased as the case progresses. The oxide of zinc mixed with boric acid, in the proportion of one part of oxide of zinc to two of boric acid, may also be used with advantage in the milder forms of the disease. When necrosis has occurred it will first be necessary to remove the dead bone, after which the case may be managed on general surgical principles. If granulation tissue develops, a thorough cleansing of the parts may be sufficient to cause it to disappear; if large in amount, it should be removed by means of the cold snare or destroyed *in situ* by the galvano-cautery, nitrate of silver, or chromic acid. The last agent yields better results and is more easily manipulated than the others.

Where the disease is of the symptomatic variety much more energetic measures must be undertaken, and if the pain is intense, cold applications to the mastoid process are indicated. This is most easily effected by using the Leiter coil (Fig. 81) or the aural ice bag (Fig. 70). The local abstraction of blood by means of the artificial leech may also give relief where the pain is very severe. It is to be applied behind the ear over the mastoid process, since the symptomatic variety is indicative of the fact that this region is affected. From a healthy adult from two to four ounces of blood may be removed; and in the very early stages this plan of local bloodletting, followed by the application of cold, may prevent further progress. If this fails, or if the condition has advanced too far to be aborted, a long deep incision should be made through the tumefied tissues which are seen to encroach upon the lumen of the canal close to the membrana tympani. This incision completely divides the soft parts down to the bone. The short curved bistoury is carried into the canal as far as the drum membrane, and is plunged quickly into the bulging supero-posterior wall until the point is felt to impinge upon the bone; it is then drawn outward, the point still being pressed firmly upon the bone. In this way the periosteum is divided and tension relieved. The incision should not be less than half an inch in length, and may be even longer; the bleeding is very free, a fact which contributes largely to the benefit derived. It is to be borne in mind that the external otitis here is a manifestation of an inflammatory process within the upper part of the tympanum itself. We are therefore, in making the initial puncture, to carry the knife upward, backward, and inward beyond the inner extremity of the bony canal, through the membrana flaccida, into the tympanic vault (Fig. 87). The incision is completed in the manner above described by drawing the knife outward along the supero-posterior wall of the meatus. In this way the mucous folds within the tympanum are divided, and the congestion within the middle ear reduced. Where the tumefaction in the canal is due to the presence of pus, evacuation through the meatus is not sufficient, and it is imperative that the mastoid cells should be at once opened and every vestige of diseased bone removed.

Where the inflammation has led to a diminution in the calibre of the meatus through hypertrophy of the bony walls, it is sometimes necessary, in order that the function of the organ may be preserved, to attempt a restoration of the channel to its normal size. When a very small passage remains, gradual dilatation, if systematically carried out for a long time, may prove satisfactory. This is best accomplished by inserting into the canal a small aluminium tube, which will just pass through the constriction. The patient is to wear this for one or two days, when it is to be removed and a little larger tube inserted. It is seldom possible, however, to promise that the tube may ever be dispensed with permanently, for when it is removed the parts very quickly resume their original position. The diameter of the meatus may be very considerably increased by carrying out this treatment, and the patient should learn to insert the tube himself, wearing it during the day and removing it at night. Its presence causes no inconvenience, and effectually relieves the impairment of hearing due to the diminished size of the passage. Pomeroy has suggested the use of small rubber tubes stretched over a silver probe to enable them to be inserted through the stricture. After they have been properly placed the probe is withdrawn and the tube resumes its original dimensions, thus exerting by its elasticity a constant dilating force against the surrounding walls. This plan has proved advantageous in some cases, but relapses have taken place, even after the condition was apparently cured. Where the channel is so narrow that only a fine probe can be passed, and the use of a tube is impossible, it is well, for the first few days, to carry a very small, tightly wound pledget of cotton through the constriction by means of the forceps; this cotton pledget absorbs moisture from the walls of the canal, increases in size, and dilates the passage slightly. In this way sufficient space may be gained to permit the insertion of a small tube, after which one of the plans already described may be carried out. The removal of any portion of the bony wall by means of cutting instruments is seldom attended by good results where the narrowing is symmetrical. If the passage is encroached upon by an exostosis, this may be removed. This condition will be treated in a later chapter.

ACUTE DIFFUSE EXTERNAL OTITIS.

Ætiology.—The acute form of the disease usually occurs as an exacerbation of a previous chronic condition; occasionally, however, it presents as an idiopathic disease, either from exposure to cold or as a complication of some profound constitutional infection, as epidemic influenza, scarlet fever, typhus and typhoid fevers, etc. The most frequent cause is a purulent otitis media, the tissues of the canal becoming infected by the purulent discharge in which they are bathed. This last variety does not include those cases already denominated under the term symptomatic. Injuries of the canal from mechanical violence or from the action of the potential or chemical escharotic agents may also give rise to an acute diffuse inflammation of the parts. An occasional cause is the occurrence of a furuncle in the meatus, the condition becoming general and involving the entire canal after the circumscribed process has fully developed.

Pathology.—The changes consist in a diffuse inflammation of the cellular tissue of the walls of the meatus. In the first stage the parts are intensely congested, after which there is a free transudation of the fluid elements of the blood, causing œdema; the interstices between the connective-tissue fibres become infiltrated with new cells, and if allowed to continue unchecked pus formation results. It is seldom, however, that this occurs, as relief is sought before this stage is reached. The tissues break down in this region at a very late period, on account of their density and firmness, and remain infiltrated for a long period before local necrosis results.

Symptomatology.—The subjective symptoms are pronounced and succeed each other rapidly. The first sensation is one of fullness or discomfort in the canal, quickly followed by intense pain. The constitutional disturbance is frequently quite marked, the temperature being elevated from two to three degrees above normal; considerable prostration is present; the patient suffers from headache, loss of appetite, and all those symptoms indicative of an inflammatory process in dense cellular tissue. From the swelling of the parts the meatus is rapidly occluded and the function of audition is markedly interfered with. Subjective noises are often present, but the pain is so severe that they are seldom complained of. In addition to the spontaneous pain intense pain is elicited upon touching the auricle. After a short period the surrounding lymphatic glands may become infiltrated, especially those lying immediately behind and below the auricle, any movement of the jaws is painful, and in severe cases the mouth is opened with difficulty.

Diagnosis.—We have to differentiate between a circumscribed inflammation of the meatus, an acute affection of the middle ear and mastoid, and the disease under consideration. The symptoms complained of by the patient do not differ, except in severity, from those characteristic of the circumscribed external otitis. The constitutional disturbance, however, is much more marked and the progress of the disease more rapid. The insertion of the speculum ordinarily causes but little pain and the outer third of the meatus is often found to be nearly normal in size. Deeper, however, the lumen is much diminished, the encroachment usually being from the supero-posterior wall, which seems to project downward and forward into the canal. The swelling is more pronounced as we approach the fundus and a considerable portion of the drum membrane is hidden from view. Where the membrana tympani lies very obliquely to the superior and posterior walls it apparently merges into these without any line of demarcation. This is particularly the case in infants, owing to the absence of the bony meatus; in the adult, however, if the canal alone is involved the observer recognizes that a portion of the drum membrane is concealed from view, but that the swollen wall of the canal is not continuous with the membrana tympani (Fig. 88). A sulcus can be recognized between the membrana tympani and the tumefaction. In very severe cases the swelling may be so great as to occlude the meatus completely, the opposite walls lying in contact. The surface of the tumefaction is slightly moist, presenting a dead-white color, due to the local necrosis of the superficial epithelial cells. If these are wiped away the surface appears reddened and moist. This desquamation of the superficial cells is often a very prominent feature of the disease and may render the diagnosis extremely difficult. These cells, as they are rapidly cast off, accumulate in the canal and, owing to its contracted calibre, are with great difficulty cleared away so as to permit a view of the small portion of the drum membrane not hidden by the swollen canal wall. The swelling is intensely painful to manipulation with the probe; pressure in front of the tragus or efforts at crowding the canal upward or forward are attended with severe pain. There may be considerable œdema over the post-auricular region, and the auricle may be displaced outward and forward from the side of the head more or less prominently. Palpation along the anterior border of the sterno-mastoid muscle reveals considerable infiltration of the lymphatic glands. When this condition occurs with œdema over the mastoid the differential diagnosis between diffuse external otitis and perforation at the tip of the mastoid is possible only by speculum examination alone. It is exceedingly

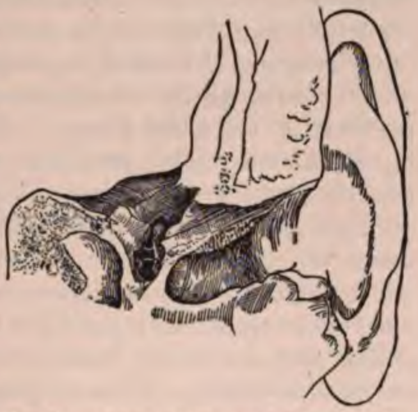


FIG. 88.—Acute diffuse external otitis, involving postero-superior canal wall. (Natural size.)

important in these cases to prolong the speculum examination sufficiently to determine the coexistence of any inflammatory condition within the tympanum. This is particularly true in the case of children, since an acute purulent otitis media, if severe, may be accompanied by a diffuse inflammation in the external meatus, and the early recognition of the true nature of the disease is a matter of great importance. The surgeon should therefore obtain a view of the drum membrane, although this may require considerable time and inflict a certain amount of suffering upon the patient. Where the parts are very much swollen and the view is obstructed by desquamated epithelium, the persistent use of small cotton-tipped probes will enable us to clear this away, and to reduce the swelling by pressure sufficiently to permit an inspection of the drum membrane, or at least of a portion of it. If this is normal in color we are warranted in the assumption that the disease is confined to the canal alone.

Prognosis.—The progress of the affection will depend largely upon the causation. If it is idiopathic the prognosis is good; if dependent upon traumatism, either mechanical, chemical, or thermal, the outcome will depend upon the severity of the injury inflicted. As complicating an acute or chronic process within the middle ear the severity of the lesion within the tympanum furnishes an index of the probable outcome of the case. When arising from a previous chronic inflammation of the canal without any special exciting cause, the disease is usually mild in character. The degree of constitutional disturbance does not indicate the probable severity of the attack, as in the early stages; the general symptoms are usually very well marked even in mild cases.

Treatment.—The first efforts should be directed toward relieving the severe pain which the patient suffers, and the attempt should be made possible to abort the process before the stage of pus formation is reached. For the relief of pain, both local and general measures are indicated. A sufficiently large dose of morphine or some preparation of opium should be administered, either by the mouth or, if the severity of the attack demands it, by the hypodermic method. The patient should be confined to bed and kept as quiet as possible; it is also well to obtain a certain amount of revulsive action by the administration of a saline cathartic. If seen very early, we may resort to local bloodletting, removing, by means of the artificial leech, not less than two ounces of blood. The site from which this is removed will depend somewhat upon the region in which the process seems to be most severe, but as a rule in the diffuse form of inflammation the best results are obtained by the abstraction of blood from the mastoid region; here preference should be given to the artificial leach rather than to the natural. Immediately after the abstraction of blood the Leiter coil should be applied to the mastoid region, or the aural ice bag may be used if this is more agreeable to the patient. If for any reason local depletion seems inadvisable, we may proceed at once to apply the ice coil or ice bag. In addition to this, considerable relief is often obtained by frequently irrigating the canal by means of the ear syringe, or, better, by employing the fountain syringe. A weak antiseptic solution, as of bichloride of mercury, one to eight thousand, or a saturated aqueous solution of boric acid, is to be used for this purpose. The warm fluid should be allowed to flow into the meatus for a period of from five to fifteen minutes, according to the relief which it affords. In this manner the parts are cleansed and the analgesic effect of the warm douche obtained. It is not necessary to remove the ice coil from the mastoid region in order to carry out this measure, and although the two would seem to be apparently opposite in action, the effect obtained is often very satisfactory. This plan of treatment should not be persisted in for more than twenty-four hours, at the end of which time, if the symptoms are not so much relieved that the patient is able to rest without the use of an opiate, and complains of but little or no spontaneous pain, more active measures are demanded. At this period no treatment, to my mind, is so efficacious as a deep free incision in the canal, relieving at the same time the tension of the parts and effecting local depletion. In order to be efficacious, the incision should be deep and of considerable length. The site of election is usually the posterior or postero-superior wall of the canal. Under illumination by means of the head mirror, a sharp stout knife, such as is shown in Fig. 87, should be carried through the swollen canal wall, close to the drum membrane, until the point of the instrument is felt to impinge upon the bone. The incision is then extended directly outward for from one half to three fourths of an inch, dividing all the overlying structures, the point of the knife being kept in contact with the bone throughout the entire length of the incision. When possible, the operation should be performed under nitrous oxide anæsthesia. The relief is almost immediate, and is complete usually at the end of twelve hours. Hartmann* strongly advises against incision in the acute form of diffuse external otitis, asserting that improvement never follows the procedure, while frequently the condition is much aggravated. Certainly this has not been my experience, although I hesitate to differ with so high an authority. The only possibility of this measure inflicting injury would be, it seems to me, in cases where the field of operation had not been properly cleansed. If the canal is freely irrigated before the incision is made I can see no reason why the result should be anything but satisfactory. After the operation the ear is to be syringed every two to four hours with a mild antiseptic solution. This irrigation is to be continued until the local condition becomes normal, the frequency being diminished gradually. Complete resolution with restoration of the normal calibre of the canal is frequently rather slow, and may not occur for several weeks. During this period the canal is apt to be the seat of a desquamative inflammation, the epithelium being rapidly thrown off, while at the same time a certain amount of serous transudation takes place, causing a thin turbid discharge from the canal. In this condition the meatus offers a favorable site for the development of aspergillus, and our efforts at cleansing the parts should not cease until the discharge has entirely disappeared. For the first few days the most relief will be obtained by the use of one of the antiseptic solutions, the canal being cleansed from two to four times daily, according to the amount of discharge. After the discharge has ceased the use of any fluid in the canal rather prolongs the process, and the parts will more quickly return to their normal condition if the walls of the meatus are dusted lightly with some antiseptic or astringent powder, such as finely divided boric acid, oxide of zinc, dermatol, bismuth subnitrate, or any similar substance. If it is necessary to leave the treatment largely to the hands of the patient, alcoholic solutions may be used in place of powders. Of these, a four- or eight-per-cent solution of boric acid in dilute alcohol is probably the most efficacious. If the discharge continues, after the use of the powders and upon thoroughly drying the ear by means of the cotton pledget, we find that the cutaneous surface is reddened and moist, a stimulating application, such as a solution of nitrate of silver, lightly brushed over the canal will frequently cause the walls to return rapidly to their normal condition. In making these applications a comparatively mild solution (about ten grains to the ounce) should be used at first, the strength being gradually increased according to the indications. These applications may at first be made daily, and afterward at longer intervals. If the disease is not seen in its early stages and, in spite of our efforts, there is considerable destruction of tissue, the affection may result in a perichondritis of the auricle, with partial necrosis of the cartilaginous framework. The treatment of this affection has already been considered. If our efforts to limit the pathological process to the soft parts are unsuccessful and there is an involvement of the underlying osseous structures, the case is to be dealt with according to the rules laid down for the management of acute inflammation of the mastoid process.

---

* Krankheiten des Ohres, Berlin, 1889, p. 99.

In every case of acute inflammation of the external meatus it is to be remembered that so long as we confine the process to the canal walls we have an affection, the management of which is comparatively simple. The danger is that it may either extend to the bony or cartilaginous structures, on one hand, or may involve the tympanic cavity secondarily, in which case we have to deal with a suppurative process within the middle ear. Moreover, where extension to the tympanum occurs, it is the upper part of the cavity which is involved. As this portion of the tympanum is richly supplied with cellular tissue, the complication constitutes a menace to life.

CROUPOUS AND DIPHTHERITIC EXTERNAL OTITIS.

The diseases included under the above heading constitute, in reality, but minor subdivisions of diffuse external otitis. Since the epidermis covering the meatus differs in no respect from that covering other portions of the body, we have no reason to presume that it should be exempt from the above special types of inflammation. Under favorable conditions the germ either of croupous or of diphtheritic inflammation may find lodgment within the meatus and produce there its characteristic exudation. The croupous form is less commonly observed than the diphtheritic. Like a croupous inflammation in other portions of the body, it is characterized by a white, thick, velvety deposit on the surface of the membrane involved, consisting of coagulated fibrin containing within its meshes white blood corpuscles. This deposit lies immediately upon the surface, and can be detached from the underlying structures without the rupture of blood vessels. It is probable that certain conditions of the general health render the patient particularly prone to this form of inflammation. The condition known as hyperinosis, or an increase in the fibrin elements in the blood, is undoubtedly the chief predisposing factor. Given this general condition, and a simple inflammation of the epidermis lining the meatus, the lodgment of the specific germ of croupous inflammation will ordinarily be followed by a change from the simple type to the croupous form.

The diphtheritic form, on the contrary, is most frequently observed as a complication of otitis media, dependent upon either a diphtheritic inflammation of the fauces or the angina of scarlatina, although it occasionally occurs as a primary affection. When occurring as a complicating lesion, the source of infection is usually the middle ear; a purulent inflammation here, with subsequent rupture of the membrana tympani, being followed by a purulent discharge which contains the specific diphtheritic germ. Such an otitis media is accompanied by a diffuse external otitis in most cases. The external meatus is therefore in a condition favorable to the lodgement and development of the diphtheritic germ.

The physical examination reveals, in the early stages, the walls of the meatus covered with a white deposit, or, if observed only in the period of necrosis, with a grayish-white membrane, which is firmly attached to the underlying skin, and can be removed only by the use of considerable force, the removal being attended with the rupture of blood vessels. When spontaneous exfoliation has taken place, the exposed areas show a loss not only of the superficial epithelium, but also of the deeper layers, the condition being one of true ulceration. The fibrous structures of the cutis are also affected, becoming swollen and encroaching markedly upon the lumen of the passage. The condition, whether of primary or secondary origin, presents the same picture, and its recognition is not difficult. It might be confounded with croupous inflammation, but if we bear in mind that a croupous deposit separates from the underlying parts without hæmorrhage, the mistake need not be made. The severe type of desquamative inflammation of the canal, either occurring primarily or dependent upon an otitis media purulenta, may also lead to error. Here, however, the deposit is not membranous, but consists simply of necrotic epithelial cells superimposed upon each other. There is no destruction of tissue, and upon removal no ulceration remains. In the same way an aspergillus within the canal may be mistaken for a diphtheritic inflammation, but the microscope will easily reveal the true character of the disease. The history of the case will also enable a differentiation to be made between the various conditions.

The presence of a croupous or diphtheritic deposit in the external canal, when occurring as a secondary disease, is usually no serious matter, since the surface presented for the absorption of the toxine of the diphtheria bacillus is one through which this takes place very slowly ordinarily. In cases where the diphtheritic deposit in the canal is but a secondary feature of the general infection the outcome depends upon the severity of the original disease without reference to the local manifestation in the auditory meatus. Occasionally such deposits occur primarily, the germ gaining access to the external canal in some unknown way, and taking root there upon an abraded surface which has resulted from a traumatic or other cause. In such instances only very slight constitutional symptoms are apt to be present, and the danger to be feared most is that the inflammation of the external canal may extend inward and involve the tympanum, the mucous lining of which would permit general infection more easily than would cutaneous lining of the canal. Croupous deposits are of trivial importance aside from the local pain which is present, and this is no more severe than in simple diffuse inflammation.

Treatment.—The treatment of the local condition consists in the thorough and frequent cleansing of the surface involved to prevent the membrane from spreading by contiguity of structure, thus increasing the extent of the surface through which the poison may enter the circulation. A diphtheritic membrane in any situation will be exfoliated spontaneously at the end of from three to eight days. If removed by violence before this time, blood vessels are opened, and the raw surface becomes covered very quickly by a new deposit, while the laceration of the vessels rather favors the absorption of the poison. It is wise, therefore, to confine our efforts to keeping the parts thoroughly cleansed, in this manner diminishing the activity of the germ, taking care that our efforts are not so vigorous as to excite any inflammatory reaction on the surrounding parts. To effect a thorough cleansing of the canal we may resort to the use of the ear syringe, or, perhaps better, the fountain syringe, employing a solution of lime water, which is allowed to flow into the canal for from five to ten minutes. In this way portions of the deposit already necrotic are removed, and a certain amount of solvent action is exerted upon the transudation which is still firmly attached to the parts beneath. Antiseptic solutions may be used here, the strength of the solution being somewhat greater than that employed for ordinary cleansing purposes. In this way the deposit is rendered inert, while at the same time, by its presence, it protects the surface to which it is attached, and when it exfoliates spontaneously the denuded surfaces are protected by the presence of granulation tissue, which offers a barrier to local infection.

In addition to irrigation, certain medicinal preparations may be applied to the deposit by means of the cotton applicator; of these, I think the solution of ferric sulphate in the full strength is by far the most efficacious. This causes a rapid necrosis of the superficial layers of the pseudo membrane, while at the same time it exerts no irritating action, even if it touches parts which have not yet become affected. This local necrosis inhibits or stops completely the growth of the germ, putting an end both to its toxic effect upon the general system and to its further local propagation. A croupous exudate may be managed in exactly the same manner, its separation being more easily effected than one of a true diphtheritic character. In this form, after the iron solution has been applied, it is often possible to remove a considerable portion of the deposit by means of the forceps without inflicting any injury upon the cutaneous lining of the canal. The administration of constitutional remedies will be governed by the same rules which apply to similar deposits located in the fauces. Remembering that a croupous exudation has for its predisposing cause a certain blood condition, it is wise to administer the tincture of the chloride of iron in large doses, with the hope of cutting short the attack. In the same manner a diphtheritic membrane appearing in the meatus, if accompanied by the characteristic constitutional symptoms of septic infection, demands the free use of stimulants and such drugs as may be believed to mitigate the action of the poison. The various local complications do not differ from those already mentioned under acute external otitis.

HÆMORRHAGIC EXTERNAL OTITIS.

Under this term Politzer* has described a disease of the external auditory meatus characterized by the presence of vesicles upon the walls of the canal. The inferior and anterior walls are usually the seat of the manifestation, although the other walls are occasionally affected. These vesicles are filled with a bloody fluid, and if allowed to remain, disappear spontaneously at the end of a few days, their site being marked by an excoriated area.

The disease may occur either as a primary affection or as a complication of an acute inflammatory process within the tympanum. The constitutional symptoms are very well marked, and consist of intense local pain, which frequently assumes a neuralgic character, spreading over the entire side of the head; the temperature is elevated to from 99° to 102°, and there is a marked prostration; occasionally delirium is present. The occurrence of this condition in the severe forms of tympanic inflammation which complicate constitutional diseases of the infectious type, particularly epidemic influenza, seems to show that the condition is indicative rather of a marked general infection than of any distinct local pathological process. In cases where we meet with this form of external otitis as an idiopathic disease, I am more inclined to consider it as either a tropho-neurosis similar in many respects to herpes, or, if the deeper layers of the canal are involved, as an accidental complication of a simple diffuse otitis. The latter view is that taken by Gruber,† and this seems to be entirely tenable. It is not improbable that the extravasation of blood cuts short the inflammatory process in the same manner as local depletion by artificial means, when the above measure is employed therapeutically in inflammation of the canal.

---

* Lehrb. der Ohrenheilk., Stuttgart, 1893, p. 154.

† Lehrb. der Ohrenheilk., Vienna, 1888, p. 289.

Treatment.—The primary indication for treatment is to relieve the constitutional symptoms, the local condition being unimportant and requiring but little attention. The intense suffering must be relieved by the administration of free doses of morphine hypodermically. When the neurotic symptoms are well marked the administration of bromide of sodium in full doses will do much to render the patient more comfortable. Complete rest should be insisted upon. The diet of the patient should consist mostly of fluids for the first twenty-four or forty-eight hours. The disturbance of the nervous system frequently brings about severe constipation, which in turn increases the severity of the local pain. It is well, therefore, early in the affection to administer calomel in small repeated doses until the effect upon the intestinal canal is obtained, its action being aided, if necessary, by a saline cathartic. Locally very little need be done, the condition within the canal being kept under observation in order that any tendency toward inflammation of the middle ear may be readily recognized and proper measures instituted to check it. If the vesicles are of considerable size they may be opened with a delicate knife, the walls of the vesicles being preserved as much as possible to protect the denuded areas within the canal. In case of spontaneous rupture the site of the vesicles may be lightly dusted with zinc oxide, lycopodium, bismuth, or any bland powder which will protect them until they are covered by normal epithelium. Occasionally these vesicles are located upon the tympanic membrane, in which event the pain is of unusual severity and the constitutional symptoms are correspondingly increased. In such cases it is wise to open the vesicles as soon as they appear, since almost immediate relief follows. Care should be taken that the canal is in a thoroughly aseptic condition before the operation, and the operator should guard against introducing the knife too deeply for fear of wounding the deeper layers of the drum membrane, and of opening into the tympanic cavity. The local tenderness renders manipulation difficult, and, unless the head is firmly held by an assistant, either of the above accidents is liable to occur. The sensitiveness of the region may be reduced somewhat by filling the canal with a ten-per-cent aqueous solution of cocaine about twenty minutes before the operation is to be performed. This solution must, of course, have been previously sterilized by boiling.

CHAPTER XIII.

IMPACTED CERUMEN.

WHILE constituting a condition which differs in no respect from that present when any foreign body is present in the meatus, this disease is of such common occurrence that it seems wise to consider it under a separate chapter.

Ætiology.—The causes which lead to this condition depend either upon the production of an increased amount of the normal secretion of the ceruminous glands, or upon an interference with its regular discharge from the canal. In health cerumen is continually formed by the glands found in the meatus, and is discharged from the canal constantly, but in such small quantities that its presence is unnoticed. Any obstructive condition interfering with this process leads to an accumulation of the secretion within the meatus, and if it exists for a long period of time a considerable mass will accumulate, varying in size and density according to the activity of the secretory process and the length of time that the obstruction has existed. The conveyance of the product along the meatus is effected principally by the action of the jaws during mastication and speaking. With every motion at the intermaxillary articulation the anterior and inferior walls of the canal are moved, on account of the intimate relation between the tragus and the capsular ligament of the articulation. This motion, when the canal is of normal size and shape, acts in such a manner that any foreign body within the fibrous meatus is moved constantly toward its orifice. If the canal presents certains anomalies in curvature or if the orifice is very narrow, the force may have exactly the reverse effect, and any body lying within the passage may be carried in the opposite direction—that is, deeper and deeper into the canal toward the drum membrane. If a small mass of cerumen collects in the canal its mere presence causes an increased amount of secretion from the glands lying in the immediate vicinity, while, at the same time, it acts as an obstruction to the outward passage of the product of the glands lying deeper within the channel.

Although the causes stated are those most frequently operative in the production of the impaction of cerumen, it must be remembered that the secretory power of any gland may be modified by interference with its nerve supply. Under certain conditions we are warranted in considering that the disease is of a tropho-neurotic character. It is certain that the opposite condition, or one in which the cerumen is diminished in quantity is frequently encountered in proliferous inflammation of the middle ear. Proliferous otitis media frequently depends upon some perversion of the trophic nerve supply, and we are warranted in assuming that an increased amount of cerumen may occasionally occur from tropho-neurotic causes.

Pathology.—Upon removal of these masses from the meatus they are found to contain not only the oily substance which is normally secreted by the parts, but also certain vegetable spores, the presence of which is purely accidental. The mass is occasionally covered by desquamated epithelium, while not infrequently we find in the centre a foreign body which has found its way into the meatus at some time and has formed a nucleus, about which the normal secretion has collected.

This description applies to the simple cases of impacted cerumen. When, however, the masses attain considerable size the pathological process is more complex, and there is in addition a chronic desquamative inflammation of the deep canal dependent upon the presence of the foreign body. For the same reason the glands are probably stimulated to increased activity. As long as the mass consists of cerumen only, no considerable changes are wrought upon the bony walls of the passage; when added to this, however, an inflammation of the desquamative type is set up by the presence of this foreign body, the osseous walls may be partially destroyed or the deep part of the canal may be enormously dilated. This is especially prone to take place in the region of the posterior wall, and the pneumatic spaces of the mastoid are obliterated. In some instances a chronic osteitis is developed by the pressure, and the mastoid cells not only disappear, but the entire process becomes sclerosed and of ivory-like hardness. The membrana tympani may be perforated by the pressure, and the removal of the mass may then reveal extensive pathological changes within the middle ear.

Symptomatology.—The symptoms dependent upon the condition vary with the size of the mass, with its location, and with the amount of secondary inflammation which its presence has excited. The lumen of the meatus may be encroached upon to a considerable extent without any noticeable impairment of the auditory function, or without the appearance of any subjective symptoms, such as tinnitus, autophony, or a feeling as if the canal were stopped. On the other hand, a very small mass may be so situated as to give rise to prominent symptoms. If it is in such a position that the membrana tympani is pressed upon, the subjective symptoms are apt to occur early, and the function of the organ may be appreciably interfered with, even though the mass be small. Again, a large collection of cerumen may lie in the cartilaginous meatus and almost completely occlude its lumen without causing any symptoms referable to the ear. Frequently the first intimation of any trouble will be the occurrence of sudden impairment of hearing following a plunge bath, when, on coming out of the water, the ear feels "stuffy" and full. These sensations are at first attributed to the presence of water in the canal. The efforts of the patient to remove this failing to relieve the discomfort, he seeks advice, and an examination reveals the presence of a mass which, from its size, must have been in the canal for a considerable period of time. The sudden access of the symptoms is due to the displacement of the plug by the water which has entered the meatus, causing it to assume a position where it completely obstructs the passage. In other cases the patient becomes conscious that the power of hearing is gradually but constantly diminishing; coexistent with this impairment of function subjective noises make their appearance, at first causing but little annoyance, but subsequently becoming so loud and persistent as to cause him to seek relief. Where the occlusion is marked the patient often complains of autophony, hearing his own voice as if it came from within the head. This symptom is particularly marked where the affection is confined to one side. Occasionally the mass may give rise to a severe neuralgia, not confined to the ear alone, but spreading over the temporal and supra-orbital regions, and sometimes involving the entire trigeminal distribution.

Sometimes this affection of the sensory nerves produces a feeling not so much of pain as of numbness, involving the aural region or the entire side of the face.

One of the most common reflex disturbances is cough. So common is this that examination of the ear is essential in the investigation of every case when complaint is made of this symptom alone. This cough is spasmodic in character, and from its severity may induce so much congestion of the larynx as to mislead the physician into believing that the laryngeal condition is the cause rather than the effect of the symptom.

Not only is the auditory function perverted or impaired, but also the mental condition of the patient may be disturbed. The patient gradually finds that he is unable to concentrate his thoughts upon any one particular subject, and that all mental processes are slow. The condition may become so marked as entirely to unfit him for any occupation requiring the exercise of his mental faculties. This disturbance is dependent entirely upon reflex action, and not upon the impairment of the hearing. Attention is particularly drawn to it from the fact that parents are often inclined to consider children inattentive when they are really suffering from a reflex disturbance dependent upon some pathological process within the ear. In these cases, unless attention is particularly directed to this organ by an impairment of hearing, serious errors are liable to occur.

Under this same head we must remember that interference with the function of the ear of the opposite side may result from the presence of a foreign body within the meatus. While this phenomenon is rarely prominent, every one who has carefully tested the hearing in both ears, in cases where the canal of one side has been occluded by a foreign body, must have noticed that we seldom find the ear on the unaffected side normal, although the patient may be conscious of no impairment, and if questioned will usually reply that the other ear is perfectly sound. When we remember the influence which a sounding body held before one ear has upon the sensitiveness of the organ of the opposite side, it is not strange that an occlusion of the external canal upon one side may seriously interfere with the hearing power of the opposite ear.

So far we have considered simply reflex disturbances of a sensory nature; many cases have been reported, however, in which epileptiform seizures have resulted from the presence either of impacted cerumen or of some other foreign body within the external auditory meatus, the attacks being entirely relieved upon its removal. Dizziness may occur from the direct pressure of the impacted cerumen upon the drum membrane, by which the attached ossicular chain is crowded inward, increasing labyrinthine pressure; it may result also from reflex disturbances due to circulatory changes within the semicircular canals or the intracranial centres.

When the impaction takes place in an ear which has previously been the seat of purulent inflammation, in addition to the symptoms already described, serious consequences may result from the obstruction to the free outflow of discharge. This is particularly apt to occur in cases of chronic purulent otitis media of long duration, where the discharge is small in quantity as a rule, but may be suddenly increased in amount from exposure to cold or some other cause. In these cases, the scant discharge, mixed with the normal cerumen, dries in the canal and forms crusts, sometimes of almost stony hardness, which prevent the exit of any fluid which may be formed within the middle ear during an acute inflammation of the parts. It is possible here for the pent-up secretion to find entrance into the cranial cavity, and cause death by involving the intracranial structures.

Diagnosis.—It is impossible to make a diagnosis upon rational symptoms alone, but objective examination at once reveals the condition. Upon inspecting the parts, occlusion of the canal is at once evident, and the determination of the exact nature of the mass before removal is of no importance. Attention, however, should be given to one point in the examination of these cases: it is the presence on the postero-superior wall of the canal of a mass consisting apparently of cerumen, which extends along this aspect of the meatus inward over the drum membrane, entirely or partially covering it. This appearance is almost always indicative of a preceding suppurative process within the tympanum, the foreign body being really inspissated secretion, mixed with a certain amount of normal cerumen. Before removing this, the patient should always be warned that the ear may discharge after the mass has been removed. The subsequent otorrhœa does not depend upon the removal of the mass, but upon a previously existing intratympanic suppuration. If not warned beforehand the patient may scarcely understand this. Where the meatus is entirely occluded, and a view of the deeper parts is impossible, this condition may be present, and it is often wise for the surgeon to protect himself even here, although it is not of as great importance as when the mass occupies the situation above described.

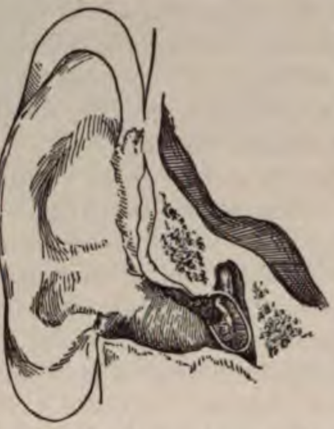


FIG. 89.—Crust on supero-posterior wall, covering a perforation in the membrana tympani. (Natural size.)

Prognosis.—The presence of a mass of cerumen in the external auditory meatus does not of itself constitute a menace to life, nor does it prevent a complete restoration of the auditory function after the removal of the foreign body. The serious consequences which occasionally follow the presence of these masses is due to secondary pathological changes which they excite, either by causing hyperæmia and subsequently inflammation, as the result of their pressure, or by setting up an inflammatory process of desquamative type in the external auditory meatus, with a resultant absorption of the surrounding bony walls or a perforation of the membrana tympani. When the affected ear is the seat of a chronic purulent otitis media, the presence of any foreign matter within the canal which may prevent the free discharge of pus from the middle ear renders the patient liable to all the serious consequences which may follow pus retention in any other part of the body. It seems curious that a mass of cerumen can offer sufficient resistance to pent-up secretions to cause them to seek an exit through the cells of the mastoid process, or to discharge into the cranial cavity, rather than to force their way past the obstruction in the external auditory meatus. The fact, however, remains that a mass of cerumen, lodged in the meatus for a considerable time, will obstruct this passage so completely that no discharge can escape. The osseous walls of the mastoid cells yield more easily to the pressure of pent-up secretions than does this mass of fatty matter. Again, in these cases the mere presence of this collection within the meatus excites a certain amount of chronic inflammation of the epidermis lining the canal, this inflammation being usually of the desquamative type. The slight amount of discharge from the tympanic cavity mixing with these desquamated epithelial cells forms a mass which is exceedingly firm, and which, increasing gradually in size, is capable of causing absorption of the osseous walls. The extent to which this may progress is unlimited, and even the cranial cavity may be invaded and a purulent infection of its contents may result. In cases where the tympanic membrane remains intact, the pressure of the mass may force this structure inward against the bony tympanic wall, and by pressure cause an atrophy of the fibrous layer of the membrane. At the same time the desquamative inflammation excited by the plug of cerumen involves the superficial layer of the drum membrane as well as the canal walls. The epithelial cells which have been cast off may adhere so firmly to the atrophic membrana tympani that upon removal of the foreign body this delicate septum may be ruptured in spite of the greatest care. Even if the membrane is ruptured, complete restoration of function may take place, although the accident adds a certain amount of gravity to the condition. It is always well, therefore, for the surgeon to protect himself by giving a guarded prognosis in any case of ceruminous impaction in the canal, in which the mass seems to be of considerable firmness, and when there is evidence that it has existed for a long time. The effect upon the opposite ear should always be borne in mind, and a careful test of the hearing power upon both sides should be made before and after removal. If the accumulation is recent, complete restoration of the normal hearing power may be confidently expected. If, however, we have reason to believe that the canal has been obstructed for several years, it is probable that the hearing will not be perfect even after the foreign body has been removed. Moreover, since complete occlusion of the meatus makes it impossible for the observer to inspect the condition of the deeper parts, an absolute opinion should be given only after the obstruction has been thoroughly cleared away and the fundus of the canal exposed to view.

These masses within the meatus exert considerable pressure upon the surrounding walls, and their sudden removal often causes a transitory hyperæmia of the parts, which particularly predisposes to the development of a circumscribed inflammation, and the appearance of a furuncle following the operation is by no means of rare occurrence. In other instances, this sudden increase in blood pressure causes a rupture of the superficial vessels, developing a blood bleb upon the walls of the meatus, usually upon the inferior wall, close to the membrana. This may attain such a size as to obstruct the canal considerably, while its color so nearly resembles that of the ceruminous deposit as to be mistaken for it. The operator is liable to inflict considerable violence upon the patient before the mistake is discovered, unless he bears the possibility of this occurrence in mind.

In one instance coming under the observation of the author this sudden removal of support to the blood vessels was followed by a serous transudation into the tympanum. The amount of fluid effused was so great as to cause intense pain from pressure upon the membrana tympani. A free incision through the membrana gave exit to the fluid, and was followed instantly by relief.

Treatment.—The first indication in a case of this character is to remove the mass, and it can not be too strongly insisted upon that when an effort to remove such an accumulation from the external auditory canal has been instituted, it should not be discontinued until the canal has been completely cleared.

An exceedingly pernicious habit is practiced, not only by physicians without special training but by many otologists as well, of ordering these patients to instil a few drops of an alkaline solution into the ear at regular intervals for the purpose of softening the mass of cerumen, to render removal more easy at a subsequent period. As we know nothing of the conditions of the deeper parts, it seems strange that this method of procedure has ever been countenanced. The symptoms caused by the obstruction may be so indefinite that almost any condition may coexist, and to allow the patient to pass from observation without determining definitely the presence of any coexisting pathological condition within the tympanum is certainly unwise. Another reason for condemning this plan lies in the fact that these masses may consist largely of dry epithelial cells, and the absorption of moisture will considerably increase their volume. In this manner great pressure will be exerted upon the walls of the meatus, causing intense suffering to the patient, and frequently leading to a circumscribed external otitis.

The cardinal rule, therefore, should always be to remove the collection at the first sitting. The instrument which is best adapted for this purpose is the ordinary ear syringe (Fig. 82). In a large majority of cases thoroughly syringing the ear will remove such a collection in a few moments. The solution to be used is a matter of considerable importance, for, as the condition of the deeper parts is unknown, the fluid should be of such a character that its entrance into the tympanic cavity, through the accidental rupture of the drum membrane or through a previously existing perforation, would be followed by no serious consequences. The syringe, therefore, must be perfectly aseptic, and the solution used should possess antiseptic properties. A solution of the bichloride of mercury—1 to 5,000 or 1 to 8,000—is the one which I prefer. The fluid should be used at a lukewarm temperature, the sensations of the patient being the guide to the exact temperature to be employed. Since the removal of the obstruction in this manner depends upon the passage of a stream of water between it and the canal wall, and the gradual crowding outward of the mass by this current, the stream should be directed where the greatest space exists between the foreign body and the canal wall. Naturally, if the current impinges directly upon the centre of the obstruction, this will be driven inward rather than outward. If, on inspection, we find that the inspissated secretion is firmly attached on all sides to the walls of the passage, it is frequently advisable to begin the process by removing a small portion of the mass close to the canal wall with a blunt curette, in order that the stream may be able to pass the obstruction. The force to be used in the procedure is best guided by the sensations of the patient; the syringing should never be painful, although in certain instances the mere entrance of the stream of water will cause considerable dizziness. It is well to begin by using very little force, gradually increasing it as may be necessary. If we were certain that the drum membrane were in its normal condition it would be almost impossible to rupture it by the use of the ordinary ear syringe. As it may be atrophic, however, care should be taken that no undue violence is employed in our efforts at removal. Where inspection reveals the canal completely stopped by the mass, and the use of the curette in the manner already described seems inadvisable, the plan usually followed is to direct the syringe so that the stream of water will impinge first upon the superior wall of the canal, next the posterior, then the inferior, and last upon the anterior wall. If the circumference of the canal is followed in this order, the instances will be rare in which the plug will not be rapidly displaced, the water at some particular point gaining entrance between the wall and the obstructing body, and rapidly forcing it outward with each successive discharge of the syringe. We occasionally meet with cases which resist all efforts at removal in this manner; in such an event the blunt curette must be used, and the collection removed piecemeal. Here it should be borne in mind that the upper and posterior portion of the drum membrane is nearer the operator than the lower and anterior portion; it is unsafe, therefore, to undermine the deposit by following the anterior wall of the canal and then attempt its removal by crowding the curette upward against the remaining portion, endeavoring to displace it by traction outward. If the drum membrane is sunken, pressure will be brought directly against this structure and much suffering will certainly follow, and in many instances it will be ruptured. It is wiser, therefore, to follow the posterior wall of the canal inward, effecting removal of the mass by pressing the curette downward and forward toward the anterior wall, at the same time employing traction outward, removing in this way so much of the mass as lies between the curette and the opposite canal wall. After the drum membrane has been once brought into view, the remaining fragments may be displaced either by the syringe or by the use of the curette, following any particular manipulation that may seem adapted to the demands of the individual case; but until this structure is seen,

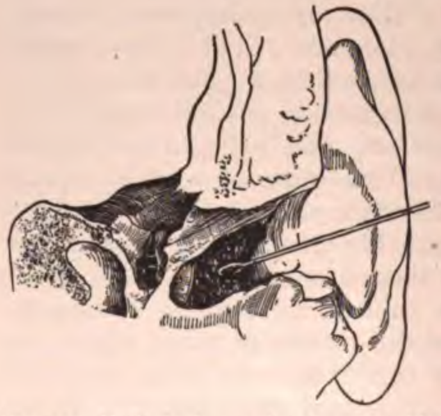


FIG. 90.—Method of removing cerumen with the curette. (Natural size.)

the plan above laid down is the one which should be followed. Where the canal is exceedingly sensitive we may vary the manipulation by removing the central portions of the mass first, a thin layer of cerumen being left on all sides closely adherent to the walls of the meatus; this tubular remnant is then broken down by introducing the curette into the channel thus prepared, when, by pressing the instrument toward the wall of the meatus, the included fragment may be extracted. Sometimes it is difficult to tunnel into the centre of a mass of cerumen on account of the extreme sensitiveness of the canal. This is particularly true of cases in which unsuccessful attempts have been made to remove the cerumen before the case comes into the hands of the otologist. In these cases the canal is frequently swollen and its lumen so narrowed that all manipulation is difficult, while the walls are so exquisitely sensitive to pressure that any attempt to tunnel into the mass causes the patient severe pain. In some of these cases the application of peroxide of hydrogen to the centre of the mass by means of a cotton-tipped applicator has so softened the cerumenous plug as to admit of its easy removal, either with the curette, the cotton-tipped probe, or the syringe. If the operator should be so unfortunate as to rupture the membrana tympani, the first care should be thoroughly to cleanse the entire field by means of an antiseptic solution, and thus reduce to a minimum the chances of infection of the tympanum.

A rather curious condition which was observed in one of my cases was the sudden effusion of a large quantity of serum into the middle ear following the removal of a mass of impacted cerumen which had lain in the canal for many years. The only explanation that could be offered in this case was that the blood vessels of the tympanum had been so compressed by the accumulation within the canal that they had lost their tone. The removal of the mass subjected them quite suddenly to the pressure of the blood current, and resulted in a rapid transudation of the fluid elements of the blood; in this case a minute rupture of the atrophic drum membrane occurred. A few hours after the operation the patient was suffering intense pain; the middle ear was full of a sero-sanguinolent fluid, which passed out as rapidly as possible into the canal through the small perforation which had been made. Feeling confident that no inflammatory condition could be present in so short a time, as strict antiseptic precautions had been taken throughout the entire procedure, the pain was attributed simply to the pressure of the fluid within the tympanum. A long incision close to the posterior attachment of the membrana tympani to the tympanic ring evacuated the fluid, the knife dividing the mucous membrane upon the internal tympanic wall at the same time that the section of the drum membrane was effected. Relief was immediate, and in thirty-six hours the opening had closed completely, the patient regaining perfect hearing at the end of ten days.

After a large mass of cerumen has been removed, it is well to insert a pledget of cotton into the meatus, directing the patient to remove it upon retiring for the night, after which it need not be replaced. Since these masses ordinarily contain a certain number of parasitic vegetable organisms, the patient should be seen once or twice subsequently to guard against the development of these parasitic growths. It is advisable during the interval between the visits that an alcoholic solution either of boric acid, in the proportion of forty grains to the ounce, or of salicylic acid, ten grains to the ounce, should be instilled into the canal twice daily; this will effectually destroy any vegetable spores which may remain, and render a reaccumulation less liable to occur. This plan of treatment is also indicated, since, in removing the mass, it is not unusual that small areas may be abraded and render the occurrence of an acute circumscribed external otitis probable. No case should be considered thoroughly cured until the entire cutaneous lining of the meatus is perfectly normal.

CHAPTER XIV.

FOREIGN BODIES IN THE CANAL.

Ætiology.—We have already described, under Impacted Cerumen, the various symptoms which may arise from the presence of any foreign substance within the external auditory canal, but here the presence of the foreign body in the canal is due to natural causes. The symptoms occasioned by a foreign body in the external auditory canal, which has either developed there spontaneously or has obtained lodgment there by accident or design, are exactly similar. We shall therefore omit a repetition of the symptomatology, and confine ourselves to the consideration of the nature of the substances which are met with in this locality, and the measures which may be necessary to effect their removal.

Pathology.—These foreign substances may be divided into two great classes: the inorganic and organic. The inorganic substances which have been removed from the external meatus are almost infinite in number. Children seem to take special delight in introducing into the meatus any article which can be made to enter it. Thus we frequently find buttons, glass beads, pebbles, sand, broken glass—in fact, anything which chance may throw in their way—introduced into this passage. A pernicious habit, frequently adopted, is the introduction of cotton into the ears of a child when it is taken out of doors on a cold day; the mother often neglects to remove this, and the child may subsequently crowd it deeply into the meatus in its efforts to dislodge it. In this situation it may remain, often for many years, and it is not uncommon in dispensary practice to find a small plug of cotton forming the nucleus of a mass of impacted cerumen, the patient being unable to state when the foreign substance was introduced.

Among the organic substances found are apple seeds, watermelon seeds, cherry pits, the shells of edible nuts, small pieces of straw which have been used by the patient to scratch the ear, or minute splinters of wood which may have been broken off in the canal during a similar effort on the part of the patient. Occasionally the body of a dead insect is found, the insect having gained entrance to the meatus accidentally, and, being unable to escape, has remained there until removed by artificial measures. A living insect usually causes such marked symptoms by its presence in the canal that immediate efforts are instituted for its removal. When leeches are carelessly applied to the region of the ear—the meatus being allowed to remain open during the operation—the animal may detach itself from the point of application, and, making its way into the meatus, may attach itself to the drum membrane and cause intense suffering. Sometimes the eggs of the common house-fly are deposited in the canal and subsequently become developed into living insects, constituting a condition distressing to the patient and disgusting to the observer.

Symptomatology.—Very little need be said about the symptoms produced by a foreign body, as we have already discussed the subject thoroughly under Impacted Cerumen.

That a foreign substance may lie in the meatus for a number of years without giving rise to any symptoms, and then suddenly make its presence felt by manifestations of unusual severity at first, appears strange; yet this is easily understood, if we consider that an irregularly shaped body may, in this locality, exert no pressure on the surrounding walls, but if suddenly displaced ever so little may impinge upon delicate and sensitive parts. Any foreign substance which increases in volume by the absorption of moisture is particularly liable to produce symptoms of increasing severity. Beans or seeds which when dry may be easily dropped into the canal become moistened by perspiration, and attain such a size that their spontaneous exit becomes impossible. While this increase in volume may not be sufficient to constitute a source of discomfort, the introduction of water into the meatus while bathing may bring about this result. Again, if there is at the same time a suppurative otitis media, the discharge from the tympanum will cause a foreign body to increase in volume. The local irritation which a foreign body exerts upon the walls of the canal increases the secretion from the cutaneous lining, the superficial epithelium is thrown off rapidly, and the canal is filled with these white, moist scales. This condition is particularly favorable for the development of the various forms of parasitic growths, or of a local infectious process ending in a circumscribed or diffuse inflammation of the walls. Naturally all of these manifestations are more common among the classes who pay little attention to personal cleanliness, or are exposed to surroundings which render local infection especially easy.

When the middle ear is the seat of suppuration, the foreign body may interfere with proper drainage, and then symptoms of pus retention ensue.

Diagnosis.—The recognition of any foreign substance lying within a perfectly patulous canal is exceedingly simple. Unfortunately, however, these patients are seldom seen immediately after the introduction of the foreign body and before efforts have been made to effect its removal. These attempts at the hands of the patient are necessarily unskillful, and result in the infliction of considerable injury to the surrounding parts. If the case is inspected at the end of a few days, the canal may be so swollen that the deeper parts are entirely invisible, the softer tissues prolapsing about the foreign body and completely hiding it; while at the same time the secretion from the parts, the desquamated epithelium, and the presence of dried blood which has followed the efforts at removal, so distort the normal appearance that an exact diagnosis is a matter of great difficulty. The parts may be so tender that only the smallest speculum can be introduced, while manipulation may be impossible. Under these conditions, our diagnosis must depend entirely upon the history; when this clearly indicates the nature of the affection with which we have to deal, it is unwise to prolong the examination, as the indications for treatment are identical, no matter what the nature of the substance may be.

Prognosis.—The outcome of the condition will depend more upon the local disturbance which is present than upon the nature of the foreign body or its location. The parts in some cases are exceedingly tolerant, while in others comparatively harmless substances may give rise to severe symptoms. Probably nothing increases the gravity of a case to such an extent as unsuccessful attempts at removal, the body itself doing less harm than unskillful efforts in this direction.

When the condition has existed for a considerable period, the presence of profuse purulent discharge will indicate that the tympanum has been invaded, while involvement of the mastoid cells or interference with the outflow of pus will be evidenced by characteristic signs.

Treatment.—The instrument which should be employed for the relief of this condition is the ear syringe. It is probably safe to say that our first efforts should always be to clear the canal, if possible, by this means alone. Although it may seem perfectly simple to remove the foreign body with the forceps, with hooks, or similar instruments, attempts to grasp hard, smooth objects usually result in crowding them deeper into the canal, where they become impacted and are removed with great difficulty. A stream of water thrown with considerable force into the meatus is usually sufficient to dislodge any obstruction, while it inflicts no violence upon the parts. The only instance in which it may be wise to attempt removal by manipulation is in the case of seeds or dried vegetable substances, which may increase in volume so rapidly when moistened as to fill the canal completely. If a sharp hook can be made to penetrate such a foreign body to a considerable depth, this is usually the simplest measure for its removal. Forceps should only be used where the body is thin and flat, and may be grasped easily in the jaws. When the contour of the body is more or less spherical, the efforts to grasp it will usually result in the instrument slipping and actually crowding the obstruction toward the fundus of the canal. Continued efforts in this direction may often force the object against the tympanic membrane, and even into the middle ear. It is sometimes possible to introduce a blunt curette between the object and the canal wall until the instrument has passed the obstruction; the instrument is then withdrawn, and the foreign body removed with it. It may be necessary, in the case of small, soft objects, to disintegrate them in the canal by instruments, and remove them piecemeal. This is particularly true of seeds, the shell being broken, and the soft interior removed by the curette, after which the remainder of the shell can be easily taken away.

The necessity of anæsthesia must be determined in each individual case. It is an error, however, to prolong the efforts at removal where the patient is extremely nervous, on account of the damage which may be done to the surrounding parts; and, unless they meet with prompt success, the patient should be thoroughly anæsthetized before continuing the operation. In some rare instances, where the condition has been neglected, the meatus may become so small that it is impossible to extract the foreign body through the natural passage. Under these circumstances a more radical procedure becomes necessary.

The patient being thoroughly anæsthetized, the parts above and behind the ear are shaved, thoroughly scrubbed with soap and water, washed with a 1-to-1,000 bichloride solution and subsequently with ether, the external meatus having been previously syringed with a two-per-cent carbolic solution or some other antiseptic fluid, and tamponed with iodoform gauze. An incision is then made from just below the insertion of the lobule, upward along the line of attachment of the auricle to a point just above the meatus, and then forward as far as the helix; the fibro-cartilaginous canal is then loosened from its attachment by means of the periosteum elevator, the instrument being applied first below and then behind, the superior wall being detached last. In the same way the periosteum of the canal is separated from the bone, and the fibro-cartilaginous tube is divided transversely as near the drum membrane as possible.

This anterior flap, consisting of the auricle and the soft parts of the meatus, is turned forward, and entrance is thus gained to the bony meatus directly, and the path to the foreign body is shortened by the length of the cartilaginous canal. This amount of gain is inconsiderable when we remember that the parts are covered with blood, and the view to a degree obstructed by the hæmorrhage. If the fibrous canal is swollen, as the result of secondary inflammation, and this is the only obstacle to the removal of the foreign body, we may be able to extract it at once after the flap has been turned forward. In case the object is found so firmly fixed in the canal that efforts at extraction are still futile, the lumen of the meatus can be enlarged with a chisel by carefully chipping away the bone from the posterior wall until sufficient space is obtained to remove the object. It is better to enlarge the passage by the removal of a portion of the osseous wall than to attempt to extract the body by forcible manipulation. The operation presents no difficulties, and we should never delay in adopting this plan whenever extraction through the natural passage seems impossible. If, in our efforts, the tympanic cavity has been unavoidably opened, this feature does not add to the gravity of the condition. The parts should be thoroughly cleansed, and the wound in the tympanic membrane will soon close, and, as a rule, the middle ear suffers very little from the accident. After the purpose for which the operation has been undertaken is accomplished, the soft parts should be replaced, and the line of incision sutured by a continuous subcutaneous catgut suture; a rubber tube should be inserted into the meatus, both for the purpose of drainage and to keep the parts in position. Sufficient drainage is secured in this way, and primary union throughout the entire length of the incision should be looked for. If there is but little inflammatory change in the tissues of the meatus as the result of the presence of the foreign body, a light tampon of iodoform gauze may be inserted instead of the drainage tube. This should extend to the fundus of the meatus to secure proper drainage, and will be found to support the walls of the canal sufficiently. Unless the temperature indicates the necessity for doing otherwise, the dressing may remain untouched for six days, when the parts will have united completely. If there has been much previous laceration of the soft parts, it is usually wise to change the dressing at the end of the second or third day. If much discharge is found at this time the canal should be irrigated; but if the parts are dry this is not necessary. The tube may be removed at the first dressing and the tampon of gauze substituted. The only unpleasant sequel which can result from the operation is the possible narrowing of the canal from cicatricial contraction, and this can be avoided if the parts are properly apposed after the operation and held in position for twenty-four or forty-eight hours.

CHAPTER XV.

EXOSTOSES OF THE EXTERNAL AUDITORY MEATUS.

Ætiology.—The development of a new growth of an osseous character in the external canal has been attributed to various causes. It was formerly supposed that a gouty or rheumatic diathesis predisposed to the condition, although statistics fail to bear out this view; and the same may be said of specific disease.

Persistent irritation of the external auditory canal, especially by the presence of a purulent secretion such as occurs in individuals suffering from neglected purulent otitis media, seems to be the most common certain cause for the development of these bony growths. Race also exerts a decided influence, the growths being more commonly met with among Europeans than among the inhabitants of our country, although among the aborigines they were of frequent occurrence, as is proved by an examination of skulls discovered through archæological research. The natives of the Hawaiian Islands also manifest the condition quite commonly, and from their aquatic habits this fact lends great weight to the argument that the irritating action of salt water exerts a most important influence in the formation of these osseous growths.

Their occasional occurrence in successive generations in the same family seems to point to a certain hereditary predisposition, although this is far from proved.

Pathology.—The portion of the canal in which these growths are most frequently found is either the junction of the cartilaginous and bony meatus or the deeper portion of the osseous channel. They occur in two forms, either as distinct pedunculated masses, or as protuberances from the bony wall arising by a broad base. In structure they may be either cancellous or hard as ivory. A single bony mass may be present, or, as more frequently happens, they are multiple, projecting into the lumen of the canal from various aspects.

Where the canal is obstructed by multiple growths, it preserves its circular form in a modified degree, the space left between the obstructing masses lying in the axis of the meatus. Where a single excrescence of large size is the cause of occlusion, the meatus is converted into a slitlike passage by the approximation of the growth to the opposite wall.

Symptomatology.—A small bony tumor in the external canal gives rise to no subjective evidence of its presence, and even where the deposit is multiple the condition may be discovered only by accident. When they attain a sufficient size to obstruct the passage to a considerable degree, the function of audition is interfered with. Certain other subjective symptoms now make their appearance: the ear feels full and stopped up, there is autophonia, and quite commonly subjective noises. The normal secretion from the walls of the meatus may collect beyond the tumor, and, being unable to find exit on account of its presence, becomes impacted, and exerts a steadily increasing pressure upon the membrana tympani and the walls of the bony meatus. This pressure tends to increase the condition from the mechanical irritation which it causes. If the accumulation is not removed artificially, the pressure may excite an acute inflammation within the middle ear, or an acute external otitis. This is especially prone to occur if water is introduced into the meatus, causing the mass to suddenly increase in volume. On the other hand, an acute inflammation of the middle ear, arising from another cause, may lead to serious results on account of the obstruction to the exit of the fluid products of the inflammation. For this last reason exostoses of large size become a menace to life, and when once discovered the patient should be cautioned to submit to an examination periodically at the hands of an expert, in order that no extensive accumulation of cerumen shall take place beyond the obstruction and cause complete occlusion.

The degree to which these masses interfere with hearing varies considerably. Even when the meatus is exceedingly narrow the power of audition may not be noticeably impaired in the ordinary intercourse of life.

Diagnosis.—Otoscopic examination usually renders the diagnosis clear at once. Where the growth is pedunculated, bulging, and broad, and especially if the surface is covered by a thin layer of cerumen, the examiner may at first be misled as to the character of the obstruction, the appearance presented in these cases being quite similar to epithelial *débris* mixed with cerumen closely applied to the wall of the meatus. Manipulation by means of the curette at once reveals the true character of the formation. Upon removal of the layer of dried secretion upon the surface by means of the curette, the integument is frequently found to be eroded and excessively tender to the touch. Undoubtedly the efforts of the patient to remove these crusts when the growth is near the orifice of the canal accounts for the steady growth in many instances. Located close to the drum membrane, and presenting as one or more small rounded protuberances, these bony excrescences may resemble closely a localized bulging in Shrapnel's membrane, but here again the probe reveals the true condition.

The clinical history, and the resistance offered to the impact of the probe, discloses the true nature of the mass. The same points distinguish it from a circumscribed external otitis, or, where the neoplasm arises from a broad base, from a symptomatic diffuse otitis externa.

Prognosis.—These neoplasms follow a different course in different cases. The progress followed by any individual growth is probably more dependent upon the causes operative in its production than upon any other condition. Thus, if it is secondary to a purulent inflammation of the middle ear, the mass will undoubtedly increase in size until the irritating discharge has been controlled. Those cases depending upon diathetic conditions alone undoubtedly advance less rapidly, and here the increase in size is seldom sufficient to demand operative treatment unless an intercurrent acute inflammation of the tympanum takes place, necessitating the removal of the exostosis to secure proper drainage. After removal the growth does not tend to reappear. We are seldom able to restore, however, the normal lumen of the meatus, even though the tumor is completely taken away. The local irritation which must necessarily follow the operation excites a certain amount of inflammation in the bony tissue which leads to hypertrophy of the wall of the bony canal, and consequent narrowing of its lumen.

The possibility of an exostosis degenerating into a malignant neoplasm should be borne in mind, especially when it is situated near the orifice of the meatus and constitutes a source of local discomfort. Under these conditions the patient continually irritates the canal in this region by the introduction of the finger or some blunt instrument to relieve the pruritus —a process which serves to keep the integument over the bony growth denuded of its superficial epithelium. From this constant local irritation a benign osseous tumor may assume the form of an osteo-sarcoma. These remarks would scarcely apply to growths located in the deep canal.

Regarding the function of the organ, the remarks already made concerning the increase in the size of the tumor may be taken as an index of its probable effect in this direction. Lesions of this character endanger life only when they act as an obstruction to free drainage from the more deeply situated parts when these are the seat of an inflammatory process.

Treatment.—Where the exostosis is deeply located, of small size, and gives rise to no symptoms, operative treatment is unwarrantable. It is well, however, to keep the patient under observation, the ear being examined at long intervals to ascertain whether the growth is progressive or has ceased to increase in size. It is surprising how narrow the meatus may become and yet impair in no degree the function of audition.

When multiple growths are present, if the hearing is not noticeably impaired, interference is scarcely called for, although the patient should be advised to submit to an occasional examination in order that any secretion which may have collected may be removed before it has become impacted so firmly as to prevent its dislodgment without great difficulty. Sea bathing should be interdicted, on account of the irritating effect of the salt water, and at the same time the patient should be cautioned against allowing fluid of any sort to enter the meatus, since by this means any collection of cerumen or of desquamated epithelial cells may become so augmented in volume as to excite severe pressure symptoms.

Where the obstruction of the meatus is almost complete, so as to interfere with the function of audition, or where the slightest increase in size would entirely close the canal, it is our duty to remove the exostosis. The precise manner in which this is to be done will vary according to its location, its form, and the individual preference of the operator. When the growth springs from a narrow base, and is situated near the entrance of the bony canal, it is usually an easy matter to separate it by a chisel introduced into the meatus, and if carefully conducted the procedure does not endanger the parts within the tympanum. When more than one growth is present, or when the condition occurs close to the drum membrane, or springs from an extensive attachment, this simple measure is not efficacious, as we have no means of protecting the deeper structures. Moreover, those growths, springing from a broad base, are usually of an ivorylike hardness, and are but little affected by chisels small enough to be introduced into the canal, the instrument frequently glancing from the surface of the tumor and inflicting serious injury upon the parts beyond. The surgical engine may be used in these cases, the base of the growth being perforated by means of fine drills, thus weakening its attachment to the wall of the meatus and permitting its removal with cutting instruments, or the entire obstruction may be cut away with a properly constructed burr. Where one is familiar with the manipulation of the dental engine, the operation, if carried out in this manner, can be performed with greater safety than by any other method.

Where the growth is so large as to render it impossible to discover the exact site of its attachment it is well to expose the orifice of the bony canal by an incision behind the auricle, and to displace the auricle forward so as to gain better access to the bony meatus. The operative technique is the same as that already detailed for the removal of foreign bodies. After this has been done, either the chisel, the drill, or the burr may be used, according to the preference of the operator.

Where the growth is located upon the posterior wall it should be remembered that, although the tumor may be eburnated, the tissue of the mastoid itself is comparatively soft, and if the chisel is employed to remove the growth it is much simpler to remove a thin lamella from the mastoid, together with the tumor, than to attempt to chisel through the base of the growth. Less traumatism is inflicted upon the surrounding parts by this procedure, and the ultimate result is correspondingly more satisfactory.

Where a purulent otitis media of long duration is present, exostoses of moderate size should be removed on account of the probability of a steady growth with the consequent obstruction to free drainage. In such cases it would be much better to detach the auricle than to attempt to operate through the canal. If this is done, we may at the same time remove all carious bone from the tympanum, and effect a cure of the purulent otitis.

Concerning internal medication but little can be said. Anti-rheumatic remedies exert practically no influence upon the progress of the local condition, and it is only where a distinct specific history can be elicited that we have any reason to hope for improvement following the administration of internal remedies. If the osseous mass within the meatus is considered to be of syphilitic origin, the administration of large doses of iodide of potassium should be tried before resorting to operative procedures. Even in these most favorable cases the results are often disappointing.

CHAPTER XVI.

WOUNDS AND INJURIES OF THE MEMBRANA TYMPANI.

Ætiology.—The partition separating the middle ear from the external portion of the conducting mechanism may suffer injury either by direct violence from instruments introduced into the meatus, or its continuity may be destroyed by indirect violence, by the sudden condensation of the air within the meatus, as when a heavy gun is fired close to the ear, or when one is in the vicinity of a heavy explosion. From the anatomical structure of the drum membrane, we remember that its superior portion is directly continuous with the integument of the superior wall of the meatus. Traction upon the auricle, therefore, especially in children, may produce a rent in this portion of the membrana. Irritating substances introduced into the canal for the relief of pain in the ear, or for toothache, may produce a superficial inflammation of the lining membrane of the canal and of the drum membrane; in the same manner a vegetable parasite growing within the meatus causes a diffuse external otitis. When moderate in degree, such an inflammation amounts to nothing more than a dermatitis, the superficial epithelium being exfoliated and the deeper layers exposed. When the inflammation is of greater intensity actual tissue necrosis takes place, and the drum membrane may be perforated, thus exposing the tympanic cavity not only to infection from the air, but also to the direct action of the substance which has excited the inflammation within the canal and has caused the perforation in the membrana tympani. As a result of this we have inflammation of the middle ear grafted upon the already existing inflammation of the external meatus. Perforation of the membrane from inflammation within the tympanic cavity is of secondary importance to the original disease, and presents no characteristic features.

Pathology.—From the introduction of instruments into the canal injury to the membrana tympani is usually effected in the upper and posterior quadrant, since this region is most accessible, the angle formed between the cartilaginous and bony canal protecting the anterior portion of the membrane from injury. When the rupture follows a sudden condensation of air in the meatus, either from a blow upon the ear or from an explosion, the rent is most frequently situated in the postero-superior quadrant, from the fact that the greatest breadth of the tympanic cavity lies in this region. Owing to some irregularity in the position of the structure an accident of this character may produce a rupture in the anterior portion of the membrane. Following traction upon the auricle the upper part is most frequently torn, and here the rupture is usually confined to the region of Shrapnell's membrane, the membrana vibrans being to an extent protected by its loose attachment to the membrana flaccida. Openings into the tympanic cavity are usually single when of traumatic origin, but occasionally multiple perforations are found. They vary in shape from a simple rent, the edges of which are only slightly separated, to an irregularly circular opening, as occurs when the force is considerable, or when the membrane is very tense. If the septum is tightly stretched the elasticity of the structure separates the edges of the tear, giving the appearance of a certain loss of substance.

Following the introduction of chemical irritants, the destruction depends upon the activity of the chemical agent instilled.

We have purposely omitted the cases of rupture following severe injuries of the cranium, since here the aural affection is of but slight importance in comparison with the fracture of the base of the skull or the cerebral concussion. The drum membrane in these cases may be injured either by a blow upon the side of the head, which suddenly compresses the air within the canal, or by a blow upon the skull which, by the force of impact, subjects the bony ring to great pressure at one point, and causes it to yield slightly, rupturing the attached membrane.

Where the middle ear becomes secondarily involved, the pathology does not differ from that of a middle-ear inflammation from any other cause except in the fact that it is usually purulent.

Symptomatology.—When the drum membrane has been torn, the first symptom is severe pain, referred to the deeper part of the organ. Coincident with this there is a very decided impairment in hearing and the development of loud subjective noises. Vertigo ordinarily occurs following a blow upon the ear, but this is due rather to a sudden increase in labyrinthine tension than to rupture of the membrana tympani. Very soon the patient is conscious of a watery discharge within the meatus, and the acute pain which was present immediately after the injury becomes dull, throbbing, and more diffuse. Upon blowing the nose the attention is at once attracted by the passage of the air through the ear, with the production of a high-pitched whistling sound. If secretion is present the high-pitched note is followed by bubbling sounds as the air passes through the fluid. Where the rent is large, the pain is usually of shorter duration than when but a small opening is present. The reason of this is that the copious serous transudation which immediately follows the injury finds a ready means of exit from the tympanic cavity, and produces less pressure upon the parts than where but a small opening exists.

The subsequent progress of the case will vary according as the middle ear is or is not involved. In the first instance a rather long-continued suppurative process not infrequently follows, while, if the tympanum escapes, the rent of its outer wall may close perfectly in a few days, leaving no symptoms behind.

Diagnosis.—A recent rupture is easily made out on examination, its irregular contour being marked by a delicate line where the rupture is linear (Fig. 91), or by an apparent loss of substance over the affected region where a circular opening is present. Through this opening the mucous lining of the middle ear appears red and congested, throwing a bright reflex back to the eye from the moisture upon the inner tympanic wall. The history of traumatism in the region of the ear, or of any injury to the skull, followed by an aural discharge, should lead to a careful examination for any evidence of injury to the drum membrane. Where the rent occurs close to the margin of the ring it may escape recognition, unless the entire line of attachment of the membrane be inspected. Wounds in Shrapnell's membrane are less easily recognized than those in membrana vibrans,

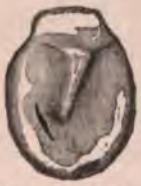


FIG. 91.—Linear rupture of the membrana tympani.

owing to the natural flaccidity of this part. Evidences of a previous rupture are the presence upon the surface of the drum membrane of minute blood clots, corresponding in position to the outline of the rent, and the coexistence of delicate radiating vessels along this line which impart a slight pinkish tinge to the affected area. These vessels become visible, owing to the increased vascularity incident to the reparative process. The presence of minute blood clots in the meatus also points to a previous injury. These appearances are of practical value only in medico-legal cases, where we may be called upon to determine the effect on the ear of a previous injury.

Prognosis.—An opening made into the tympanic cavity as a surgical procedure is one of the simplest operative measures employed. It is quite different, however, if the opening occurs as the result of an accident, when the meatus may contain an abundance of infectious material, which thus gains access to the mucous lining of the tympanum; here it is easily absorbed and produces characteristic results.

On account of this, an accidental rupture of the membrana tympani at the hands of the surgeon in attempting to remove a foreign body, either with the syringe or curette, is seldom followed by untoward results; while the same accident inflicted at the hand of the patient might lead to fatal consequences. In the one case, if proper precautions have been taken, the parts are in a thoroughly aseptic condition before the traumatism has occurred, and hence no infection follows, while the reverse is true in the latter instance.

In general, the prognosis both for the ultimate closure of the opening and the restoration of the power of audition is fairly good, if the case comes under observation before a chronic purulent inflammation has supervened. If this has occurred, the result will depend upon the condition of the parts as revealed by the examination, independent of the cause which has produced it.

Treatment.—As the surgeon, no matter how expert, will occasionally wound the membrana tympani, no instrument should be inserted into the meatus before this channel has been thoroughly cleansed. Even in removing foreign bodies by means of the syringe, the solution employed should be antiseptic in character, in view of the fact that the tympanum may be accidentally entered. Under these conditions it is only necessary to dry the parts lightly with cotton, dust a little boric acid along the margins of the wound, and occlude the meatus with a pledget of sterilized cotton. A little serous discharge may follow, in which case the patient is directed to change the cotton as frequently as it becomes saturated. No other treatment is necessary, the parts resuming their normal condition in from twelve to twenty-four hours, even when very free serous discharge has supervened.

In cases where the membrana tympani has been ruptured, the surgeon should always secure perfect asepsis by scrubbing the meatus and the surface of the drum membrane with an alcoholic solution of bichloride of mercury, of a strength 1–3,000. If the parts seem comparatively dry, the perforation should be covered with a small disk of sterilized paper moistened in sterile albolene. This is carried into the canal by means of a delicate cotton-tipped probe. In cases of linear rupture of the membrana tympani this paper dressing serves to support the parts, to maintain the asepsis of the tympanic cavity, and to cause the wound to heal without the deposit of any appreciable amount of cicatricial tissue. Where the opening in the membrana tympani is larger, as in cases of stellate rupture, and where the margins of the wound in the drum membrane have sloughed, leaving an irregular opening, the application of this paper disk is of advantage as it supports the drum membrane during the process of cicatrization and prevents the formation of a relaxed cicatrix. These paper dressings should be applied only when there is practically no discharge from the ear or in cases where the discharge is very slight and is serous in character.

When seen at a later period, or in cases where it is probable that infection has taken place, local bloodletting from the region in front of the tragus may abort the inflammation. If the opening through the drum membrane is exceedingly minute, and the middle ear contains a large amount of fluid, the wisest plan is to make a free incision through the drum membrane, at the same time incising the opposite internal wall of the tympanum. This evacuates the contents of the cavity and depletes the vessels upon its inner wall. The measure is followed almost invariably by a prompt disappearance of the symptoms, the wound closing in from twenty-four to forty-eight hours. We sometimes meet with cases in which Nature has already sealed the opening by the deposit of a small blood clot upon the external surface of the drum membrane. No attempt should be made to remove this unless there is severe pain, as healing invariably takes place if the clot is allowed to remain. Interference with it may possibly infect the cavity and be followed by severe inflammation of the middle ear. Acute or chronic otitis media following the accident calls for the treatment indicated under the discussion of these diseases.

III. DISEASES OF THE MIDDLE EAR.

THE entire middle ear, from the pharyngeal orifice of the Eustachian tube to the inner surface of the membrana tympani, is covered with mucous membrane; this is supplied with glandular structures, in some parts very richly, while in other parts they are rather sparsely distributed, for the purpose of keeping the membrane moist.

The pathological processes met with here may involve either the entire region or some single portion of it. Considerable confusion exists at present in the classification of diseases of the middle ear, and many cases in which the Eustachian canal alone is affected are classified as cases of otitis media, while, on the other hand, certain manifestations within the tympanum dependent not upon inflammatory changes, but upon certain conditions of the blood vessels distributed to the parts, are also considered under the same title. It should be remembered that the fluid effused in a simple inflammation of a mucous membrane is an increased amount of the normal secretion of the membrane, and nothing more. The presence of a purulent effusion as the primary result of such an inflammatory change in a cavity lined with mucous membrane is impossible; in order that the fluid shall be purulent, infection must take place from the outside, or the inflammation must be infectious from the first, and involve not only the mucous membrane, but the underlying connective-tissue structures. The affections in which the mucous membrane alone is involved have been denominated as catarrh of the middle ear. From the derivation of the term, this name indicates simply an increased amount of secretion. Such an inflammatory process may involve the Eustachian tube alone, giving rise to tubal catarrh or catarrhal salpingitis, or both the tube and the tympanum may be involved, in which case we have a tubo-tympanic catarrh or salpingo-tympanitis. In this last-named disease the inflammatory process is chiefly confined to the tube and seldom goes beyond the stage of congestion, changes taking place in the cavity of the middle ear being almost entirely secondary to this and depending upon the physical condition of reduced pressure within the tympanum, due to closure of the Eustachian canal. The disease is really salpingitis, which secondarily has given rise to certain physical changes within the drum cavity discernible upon otoscopic examination, and scarcely deserves recognition as an individual affection. The separation of these two varieties is made more for convenience in classification than for any other reason.

In other instances the tympanum is the primary seat of a superficial inflammation with no involvement of the connective-tissue framework. In such cases the changes are usually confined to the lower portion of the tympanic cavity or to the atrium. The epitympanic space is not involved, and the inflammatory process results in the pouring out of an increased amount of normal secretion, which fills, more or less completely, the middle ear. The mucous membrane covering the internal surface of the membrana tympani participates in the process, and the membrana may be so infiltrated as to rupture from the increased pressure caused by the pent-up secretion. The rupture of the membrane in such a case depends not so much upon a deep-seated inflammatory process as upon the increased pressure to which the membrane is subjected from the secretion within the cavity, although in severe cases it is probable that the entire thickness of the membrane is involved on account of the free anastomosis between the vessels of the inner and outer layers. After perforation has taken place this form of inflammation may become changed in character from the infection of the discharge from without, after which it runs the typical course of a purulent inflammation.

Such are the changes present in those cases where a simple catarrhal inflammation occurs within the middle-ear tract. Both in tubo-tympanic catarrh and in acute catarrhal inflammation of the middle ear we may have a solution of continuity in the drum membrane; in the tubo-tympanic form this rupture is due simply to the pressure of the fluid with which the cavity is filled. It is probable that rupture never occurs in these cases if the membrane is not atrophic from a previous pathological process. This fluid is not the result of inflammation, but of a serous transudation simply from the overdistended vessels. The fluid collects in the atrium although transudation may take place from the numerous reduplications in the upper part of the cavity, the fluid entering the atrium in obedience to the laws of gravity. In acute catarrhal tympanitis the transudation is of inflammatory origin, and this inflammatory process may be a factor of some importance in causing the rupture of the membrane, although it is certainly not the principal one. Here the atrium alone is affected, although the tympanic vault may be involved secondarily from subsequent infection of the discharge.

Where the inflammation is purulent from the start we have those structures primarily involved which are richly supplied with connective-tissue elements. By recalling the anatomy of the tympanic cavity we remember that the vault of the tympanum contains numerous duplicatures of mucous membrane, these being so fully developed in some instances as to completely fill the entire epitympanic space; the connective-tissue framework of these folds presents a favorable site for the growth of the bacteria of suppuration. When infection of this tissue occurs we have an inflammation set up which differs in no respect from a cellulitis in any other portion of the body; tissue necrosis takes place quite rapidly, and the secretion resulting from the inflammation is purulent in character from the outset. The fluid products find exit either into the atrium and then into the canal, or the membrana flaccida may be ruptured and an outlet afforded in this way, or the secretion may find its way into the mastoid cells or even into the cranial cavity when egress in other directions is prevented. Purulent inflammation occurs, as we should expect, in the more severe types of acute infectious diseases such as scarlatina, diphtheria, variola, general pyæmic infection, etc. As above stated, it may occasionally follow a simple catarrhal inflammation by infection of the discharge and subsequent inoculation of the connective tissue in the tympanic vault through this secretion.

Under the forms of chronic inflammation involving the portion of the conducting mechanism under consideration, we have those resulting directly either from a previous simple catarrhal inflammation or from a purulent process.

We include in this group those cases which give the history of repeated attacks of acute middle-ear inflammation, but in whom the membrana tympani is not perforated. Other cases present in which the membrana tympani has been destroyed over a small or large area and a permanent perforation remains. These again divide themselves into cases in which the discharge still continues after the acute disease has run its course, and those in which the residue of the former attack remains, the affection having either ceased spontaneously or yielded to treatment, restitution of the necrosed parts not having taken place.

A third class of cases comprises that variety where the inflammation is chronic from its inception and is characterized by a deposit of new tissue. To this we give the term hyperplastic inflammation. Although we may find this condition where a previous purulent inflammation has existed resulting in local necrosis, it is usually met with where no such loss has taken place. No sharp dividing line can be drawn between this variety and those following an acute catarrhal inflammation which has failed to resolve, and to which the term hypertrophic is applied.

Regarding the particular bacteriological infection which occurs in various intratympanic inflammations, much has been written of late. From the rather free communication between the tympanum and the external air by way of the Eustachian tube, it would seem almost impossible that the tympanic cavity could ever be entirely free from pathogenic organisms. It is a well-known fact that repeated examinations of secretions of the mouth, the oro-pharynx and the naso-pharynx, in a large number of healthy individuals, will reveal the presence of various forms of bacteria, some of which are entirely harmless, while others are of the pathogenic variety. When we consider that the middle ear, under normal conditions, is practically in direct communication with both the nasal and naso-pharyngeal cavity, it would seem that an absolutely sterile tympanic cavity would be rarely met with. The investigations of Presing* would seem to show that under normal conditions the tympanic cavity contains absolutely no bacteria of any description. Hasslauer,† in a series of similar investigations, has apparently proved that the normal tympanic cavity frequently contains a large number of various micro-organisms, among which may be mentioned diplococci, diplostreptococci, Friedländer's bacillus, the bacteria of decomposition, and occasionally streptococci. From these latter investigations, it seems probable that the presence of various forms of pathogenic organisms is not uncommon within the tympanum. With the mucous lining of the tympanic cavity in its normal condition these germs are not present in sufficient quantities, nor are they sufficiently active to cause any disturbance. If, however, the circulation within the tympanum becomes disturbed in any way, so as to render the tissues more vulnerable, then these organisms begin to proliferate within the middle ear, and to give rise to symptoms characteristic of their presence. As before stated, most of these micro-organisms reach the middle ear by way of the Eustachian tube. It must be remembered that in the course of general systemic infections, such as diphtheria, measles, epidemic influenza, and so forth, infection of the tympanic cavity may take place through the blood and lymph vessels. The precise character of infection causing a middle ear inflammation, therefore, will depend upon several factors. In the first place, those inflammations of the tympanic cavity occurring primarily, and not complicating an acute infectious disease, are most probably dependent upon micro-organisms whose presence in the tympanic cavity is adventitious and their development depends upon some temporary congestion of the mucous membrane within the middle ear from any slight external cause, such an exposure to cold, external traumatism, and so forth. In those cases of middle-ear inflammation complicating an acute infectious disease, such as measles, diphtheria, scarlet fever, epidemic influenza or pneumonia, a bacteriological investigation has demonstrated clearly the presence of various organisms in the discharge from the ear, the secretion examined being obtained either by paracentesis of the membrana tympani or the inoculation of the culture tube being made from the discharge present in the canal after spontaneous rupture of the drum membrane. In some cases of diphtheria, influenza, and pneumonia, the specific micro-organism of these diseases has been found in the discharge from the ear.* In many other cases, however, of the acute infectious diseases, especially of scarlet fever and measles, the infection has been due to various varieties of streptococci, staphylococci, and diplococci. As in many of these constitutional diseases the nasopharynx is frequently invaded, by an acute inflammatory process, the cultures from this region show the presence of those micro-organisms mentioned above. It seems probable, then, that the tympanic cavity was invaded directly through the Eustachian tube, and that an inflammation of the middle ear was determined, first, by the presence of a large number of these specific micro-organisms being introduced into the cavity, and, second, by the increased vulnerability of the mucous membrane of the middle ear, dependent upon the lowering of the general resisting power of the patient, due to the general constitutional infection. Clinically, we know that certain cases of acute inflammation of the middle ear are exceedingly prone to be followed by an involvement of the bony structures about the ear—that is, to mastoid inflammation—while in other cases the patient escapes without any such complication. Bacteriological investigation has shown that in two-thirds of the cases complicated by mastoid inflammation, a streptococcus is the micro-organism most frequently found.*

---

* Centralbl. f. Bakter., vol. xxv, Abth. I, p. 635, Die gesunde menschliche Paukenhöle ist keimfrei.

† Klinische Vorträge aus dem Gebiete der Otologie und Pharyngo-Rhinologie, p. 83.

---

* Hasslauer, *loc. cit.*

While the study of the various forms of bacteriological infection of the tympanum is interesting to those devoted to laboratory research, the chief interest to the otologist is the determination of the prognosis in a given case by means of a bacteriological investigation of the discharge from the ear. In the present state of medical science, it is always wise to make a culture of an aural discharge at an early date, whether this discharge appears spontaneously or is evacuated as the result of an incision in the drum membrane. The culture is easily made by inoculating one of the sterile agar tubes, furnished by the Board of Health, a sterile cotton swab being introduced into the meatus so as to mop up a little of the discharge, and then carried lightly across the surface of the agar. At the same time, it is wise to make one or two smears on sterile microscopic slides, these smears being dried and then examined microscopically after staining. The presence of a large number of streptococci in the smears or in the culture tube, should always lead the surgeon to give a doubtful prognosis as to the favorable outcome of the case. That is, where streptococcus infection is present, where these micro-organisms are found in large quantities, and where the growth of the culture tube is rapid, the patient is much more liable to suffer from mastoid involvement than where a milder form of micro-organism is found.

The behavior of any of the bacteria obtained in this way, when grown upon various culture media, will, in certain instances, materially influence the surgical procedures to be adopted in any given case. What has been said in regard to a streptococcus infection applies equally well to infections due to various other micro-organisms, it being remembered, however, that the streptococcus is a germ of great virulency, and one which having once invaded the tissues yields less rapidly to mild measures of treatment than do the other forms. We find many cases in which the various forms of diplococcus—particularly the pneumococcus—lead to involvement of the bony structures about the ear. In a doubtful case, therefore, the surgeon should always bear in mind that the rapidity of growth of any germ in the culture medium is a moderately fair index of the rapidity with which the healthy tissues will be invaded. If the micro-organism is of slow growth, and if the smear preparations show only a few micro-organisms, then the surgeon is warranted in giving a favorable prognosis at once, and is perfectly justified in assuring the patient that involvement of the osseous tissues will not occur. Moreover, he is justified in attempting to abort the acute inflammatory process by the local application of cold, where, if the affection were more virulent in character, such abortive measures of treatment would be entirely unjustifiable. It must also be borne in mind that in some cases of acute inflammation of the middle ear, where there is marked bulging of the membrana tympani and where incision of this structure is imperative, the examination of the fluid may show the discharge to be entirely free from micro-organisms. I have recently seen such a case complicating a mild attack of measles, in which the drum membrane bulged extensively in the lower and posterior portion. The membrane would certainly have ruptured had it not been promptly incised. Careful cultures made from the fluid evacuated by incision of the membrana tympani revealed absolutely no bacteria. This goes to show that under certain conditions the circulation within the tympanum may be so interfered with that we may have what may be termed a "passive" effusion into the tympanic cavity, just the same as we have an effusion into the pleural cavity in cases of chronic cardiac or renal disease. We may then have a discharge from the ear, the fluid being present in such great quantities as to rupture the drum membrane with pressure. The pain in these cases may be severe. If the case is treated aseptically, however, and infection is not allowed to occur from without, the surgeon can assure the patient that he will make a perfect recovery without further operative interference.

---

* Hasslauer, *loc. cit.*, p. 51.

CHAPTER XVII.

TUBAL CONGESTION, OR TUBAL CATARRH.

(Acute Salpingitis. Eustachian Catarrh.)

Ætiology.—This affection of the Eustachian tube usually arises from an acute coryza or an acute naso-pharyngitis, although it may be met with as a primary affection from exposure to cold. Occasionally it complicates light attacks of the exanthemata in young adults. It may depend upon the entrance of some irritating fluid into the Eustachian tube while bathing, or in using the nasal spray. Rarely it follows a blow upon the external surface of the body in this region. The chief predisposing cause is some obstructive lesion of the nose or naso-pharynx. The presence of adenoid vegetations is a particularly potent factor in its causation, since these masses easily become engorged with blood, causing venous hyperæmia of the walls of the tube, narrowing or completely closing its lumen. At the same time, the presence of this soft tissue in the vault of the pharynx affords lodgment to pathogenic bacteria inhaled during the act of inspiration, from which locality they easily find their way into the canal. Impaired general health, no doubt, renders one more liable to the disease.

Pathology.—The pathological conditions are to be considered under two heads:

First, the actual changes present in the tubal mucous membrane.

Second, the changes occurring in the middle ear dependent upon the obliteration of the tubal lumen.

Within the tube the condition is essentially one of simple venous hyperæmia, or the membrane may be the seat of a very mild inflammation following the venous engorgement. The mucous membrane becomes swollen and flabby, the walls of the tube lying in contact with each other and adhering closely on account of viscid secretion. The first change of venous hyperæmia results in a transudation of the fluid elements of the blood from the increased pressure. When the process becomes fully developed, the secretion is thick, tenacious, glairy, white in color, and by its presence may occlude the channel completely. The changes are usually most marked in the cartilaginous part of the tube, the osseous segment being but little affected.

When the Eustachian canal is obstructed from any cause he air contained within the tympanic cavity disappears quite rapidly from absorption. This results in diminished atmospheric pressure within the tympanum, and a crowding inward of the drum membrane and the entire ossicular chain by the external atmospheric pressure. If the canal remains closed ufficiently long, we shall find the drum membrane so displaced that it touches the opposite internal tympanic wall in he region of the tip of the long process of the malleus. At ts upper and lower poles its firm attachment prevents displacement.

Symptomatology.—An attack of this character, occurring n the course of an ordinary cold in the head, is usually characterized by a rather sudden onset of the symptoms. The patient complains of a feeling of stuffiness or heaviness in the ears, as though the external meatus were occluded by a foreign body, one of the most characteristic symptoms being the desire to insert the finger into the meatus in order to "clear the ear," as the patient expresses it. This manipulation is sometimes attended by momentary relief from the exhaustion of the air within the meatus when the finger is suddenly withdrawn. Sometimes, in addition to this feeling of discomfort, there is a sensation of actual pain referred to the upper part of the pharynx or the region of the tonsil. In rarer instances this pain is complained of in the region of the larynx, the sensation being as though a foreign body had become odged at the root of the tongue. Accompanying this, there s some pain radiating upward toward the ear, but when closely questioned we find that no actual pain is present in the ear.

The hearing is considerably impaired, the diminished audition seeming more prominent from the sudden onset of the attack. Subjective noises are almost always present, and may be exceedingly distressing. They are most frequently high-pitched in character, and in plethoric subjects may increase in intensity with each cardiac systole. Disturbances of equilibrium, from the sudden increase of labyrinthine pressure, may be met with, although their occurrence is not invariable. Among the rarer symptoms to which the affection gives rise is a feeling of heaviness and mental torpidity. In nervous subjects the anxiety of the patient as to the sudden impairment of hearing power is rather characteristic. The sensation of heaviness within the ears may not remain confined to this region, but may be complained of as a stiff, numb feeling extending over the entire side of the head. It is seldom that both sides are affected to the same degree, although examination will seldom show a perfectly normal condition in the organ which the patient asserts is healthy.

Occasionally cases are met with in which an attack of tubal congestion follows any slight exposure to cold. While not severe enough to narrow the lumen of the canal to an extent which interferes sufficiently with audition to direct the attention of the patient to the ear, the subjective symptoms are very pronounced. They consist in the sensation of a foreign body in the pharynx, or sometimes of an acute pain at the root of the tongue, occasionally severe enough to interfere with deglutition. The patient does not complain of the ear, but refers all the symptoms to the pharynx or larynx. These manifestations are met with most frequently among neurotic subjects, and the attacks may be repeated at short intervals. Occasionally they occur in individuals who are not neurotic, and in these patients the symptoms are more acute, and close questioning will usually elicit a history of a slight impairment of audition.

Diagnosis.—A. *Physical Examination.*—An inspection by reflected light reveals the drum membrane drawn inward towards the internal tympanic wall, for which reason the inferior segment seems abnormally broad from above downward, while at the same time the transverse diameter of this segment seems to be increased (Fig. 92). The handle of the malleus is foreshortened, the short process is prominent and appears lighter than normal, and in some cases it may be impossible to make out the contour of the manubrium, owing to the extreme degree of retraction, the shaft being entirely hidden behind from the prominent short process. Both the anterior and the posterior folds are exaggerated, the annulus tendinosus is prominent, and the membrana flaccida may participate in these changes, being drawn inward upon the neck of the malleus and closely applied to it, although this latter condition is not ordinarily present. The color of the membrane is normal, its lustre is preserved, and the light reflex is either absent, displaced, or multiple. The stretching to which the parts have been subjected causes the membrane to appear thinner than normal, and the underlying intratympanic structures may be clearly discerned through it. In the upper and posterior segment we are often able to recognize the long process of the incus, the incudo-stapedial articulation, the posterior crus of the stapes, and sometimes the tendon of the stapedius muscle. The niche of the round window may also be visible. The lining membrane of the tympanum, as viewed through this thin covering, presents no evidences of congestion. The physical appearances are due entirely to the diminution of atmospheric pressure within the tympanic cavity, this region itself being unaffected.

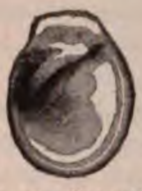


FIG. 92.—Retraction of membrana tympani from closure of the Eustachian tube.

If the ear is inflated, either by means of the Eustachian catheter or by the Politzer method, the auscultation tube being employed to furnish us with information concerning the condition of the parts, we shall find that the canal is opened with difficulty, the air either not entering the middle ear at all or only after several attempts at inflation. When the catheter is used, the first few compressions of the bulb result in the production of a harsh, low-pitched, rasping sound, which we recognize as originating in the vault of the pharynx, and not depending upon the entrance of air into the middle ear. This is caused either by the current being forced through the thick viscid secretion with which the parts are covered, or by impinging directly upon the mucous membrane of the passage, which from the œdema is thrown into irregular folds and deflects the current of air from its original direction. As inflation is continued these pharyngeal sounds disappear, and the air enters the tube, either from the dislodgment of the mucus or from the displacement of the folds in the mucous membrane by manipulation of the catheter. Within the tube the current may meet an obstruction, either from an agglutination of the walls of the tube or from the lodgment of a mucous plug at the isthmus. When familiar with the ausculin intensity with each cardiac systole. Disturbances of equilibrium, from the sudden increase of labyrinthine pressure, may be met with, although their occurrence is not invariable. Among the rarer symptoms to which the affection gives rise is a feeling of heaviness and mental torpidity. In nervous subjects the anxiety of the patient as to the sudden impairment of hearing power is rather characteristic. The sensation of heaviness within the ears may not remain confined to this region, but may be complained of as a stiff, numb feeling extending over the entire side of the head. It is seldom that both sides are affected to the same degree, although examination will seldom show a perfectly normal condition in the organ which the patient asserts is healthy.

Occasionally cases are met with in which an attack of tubal congestion follows any slight exposure to cold. While not severe enough to narrow the lumen of the canal to an extent which interferes sufficiently with audition to direct the attention of the patient to the ear, the subjective symptoms are very pronounced. They consist in the sensation of a foreign body in the pharynx, or sometimes of an acute pain at the root of the tongue, occasionally severe enough to interfere with deglutition. The patient does not complain of the ear, but refers all the symptoms to the pharynx or larynx. These manifestations are met with most frequently among neurotic subjects, and the attacks may be repeated at short intervals. Occasionally they occur in individuals who are not neurotic, and in these patients the symptoms are more acute, and close questioning will usually elicit a history of a slight impairment of audition.

Diagnosis.—A. *Physical Examination.*—An inspection by reflected light reveals the drum membrane drawn inward towards the internal tympanic wall, for which reason the inferior segment seems abnormally broad from above downward, while at the same time the transverse diameter of this segment seems to be increased (Fig. 92). The handle of the malleus is foreshortened, the short process is prominent and appears lighter than normal, and in some cases it may be impossible to make out the contour of the manubrium, owing to the extreme degree of retraction, the shaft being entirely hidden behind from the prominent short process. Both the anterior and the posterior folds are exaggerated, the annulus tendinosus is prominent, and the membrana flaccida may participate is present, we may find that the patient hears the lower notes of the scale fairly well, while at the same time bone conduction is greatly diminished, and the upper tone limit lowered. This is probably due to a slight rarefaction of the air within the tympanum, which, according to Politzer, instead of increasing labyrinthine pressure, reduces it. It may also depend upon the particular susceptibility of the auditory nerve to mechanical irritation, causing a condition of hyperæsthesia, which favors the perception of low notes, at the same time reducing bone conduction.

These variations, while apparently confusing, in no way detract from the value of the functional examination, as they indicate the existence of a secondary labyrinthine condition. This interference with the perceptive apparatus is perfectly amenable to any treatment which will remove the tympanic disturbance upon which it depends, and its recognition is of importance since it shows, in any given case, a particular intolerance of the labyrinth to changes in pressure.

It is not unreasonable to suppose that in any of these cases of sudden closure of the Eustachian tube the labyrinth suffers a certain amount of traumatism, the same as when the ear is exposed to the influence of sudden loud sounds, such as those produced by explosions, etc. It is a well-known fact that under these conditions a train of symptoms is found which we consider characteristic of concussion of the labyrinth. In the same manner, the sudden increase of labyrinthine pressure due to pressure of the stapes upon the perilymph may cause a condition of hyperæsthesia of the auditory nerve, and change, to a marked degree, the reactions found on functional examination. When this occurs the case is one of labyrinthine disease, acute in character, and readily amenable to treatment, and is due to the sudden and absolute closure of the Eustachian tube. Our functional examination reveals this labyrinthine condition, and should not be condemned because it enables us to distinguish a complicating labyrinthine lesion, and emphasizes it rather more than the tubal stenosis. The clinical history and appearance of the drum membrane will render an error in diagnosis exceedingly rare. When the auditory nerve is in a condition of hyperæsthesia the perception of low tones is well preserved, and it may happen that the lower tone limit is not elevated to the degree which we should expect to find in sudden closure of the Eustachian tatory signs we recognize that the sound produced by the insufflated air is nearer the ear, and is of a less harsh character than when the obstruction is at the pharyngeal orifice, while the sensation of the sound being produced close to our own ear is wanting. At last we recognize the entrance of the current into the tympanic cavity, the quantity of air entering being at first small and the sound produced by its passage being consequently high-pitched. If the swelling is excessive, the entrance of the air into the tympanum is irregular, instead of occurring freely with each compression of the bulb. When at length the lumen has been sufficiently cleared to permit the free entrance of the current, the sudden replacement of the drum membrane to its normal position is recognized by the examiner by the occurrence of a sharp, almost metallic click, as the membrane is forced outward.

B. *Functional Examination.*—Upon testing the hearing, we find the power of audition for the whisper markedly reduced; tests with the acoumeter and watch will also show reduction in the hearing power, although to a relatively less degree than to the voice. The lower tone limit is elevated, in the great majority of cases being above 32 V. D., and sometimes two octaves higher than this. The upper tone limit is frequently reduced, or it may be normal. When reduced, the change is caused by pressure upon the delicate structures lying in the lower turn of the cochlea. The bone conduction is augmented especially for the low notes of the scale, Rinne's experiment being negative for the lower notes and a reduced positive result being found as we ascend the musical scale. The vibrating tuning fork, placed upon the vertex or upon the forehead, is referred to the poorer ear in almost all cases. These reactions may be considered as typical, and will be found in a very large majority of instances. Certain conditions may exist, however, which will modify them, to which attention should be given. In patients over forty years of age the tuning fork may not be lateralized to the side most affected, and the bone conduction may not be increased in comparison with the normal standard. A similar change may be found upon applying Rinne's test. The remarks made in the chapter on Physiology upon the diminution of bone conduction as age advances explain this apparent deviation from the classical reactions. When the patient is seen very early, and before much retraction of the membrana tympani is present, we may find that the patient hears the lower notes of the scale fairly well, while at the same time bone conduction is greatly diminished, and the upper tone limit lowered. This is probably due to a slight rarefaction of the air within the tympanum, which, according to Politzer, instead of increasing labyrinthine pressure, reduces it. It may also depend upon the particular susceptibility of the auditory nerve to mechanical irritation, causing a condition of hyperæsthesia, which favors the perception of low notes, at the same time reducing bone conduction.

These variations, while apparently confusing, in no way detract from the value of the functional examination, as they indicate the existence of a secondary labyrinthine condition. This interference with the perceptive apparatus is perfectly amenable to any treatment which will remove the tympanic disturbance upon which it depends, and its recognition is of importance since it shows, in any given case, a particular intolerance of the labyrinth to changes in pressure.

It is not unreasonable to suppose that in any of these cases of sudden closure of the Eustachian tube the labyrinth suffers a certain amount of traumatism, the same as when the ear is exposed to the influence of sudden loud sounds, such as those produced by explosions, etc. It is a well-known fact that under these conditions a train of symptoms is found which we consider characteristic of concussion of the labyrinth. In the same manner, the sudden increase of labyrinthine pressure due to pressure of the stapes upon the perilymph may cause a condition of hyperæsthesia of the auditory nerve, and change, to a marked degree, the reactions found on functional examination. When this occurs the case is one of labyrinthine disease, acute in character, and readily amenable to treatment, and is due to the sudden and absolute closure of the Eustachian tube. Our functional examination reveals this labyrinthine condition, and should not be condemned because it enables us to distinguish a complicating labyrinthine lesion, and emphasizes it rather more than the tubal stenosis. The clinical history and appearance of the drum membrane will render an error in diagnosis exceedingly rare. When the auditory nerve is in a condition of hyperæsthesia the perception of low tones is well preserved, and it may happen that the lower tone limit is not elevated to the degree which we should expect to find in sudden closure of the Eustachian tube. Distressing tinnitus and vertigo, the latter being especially prone to occur on inflating the middle ear, together with a lowering of the upper tone limit before inflation, render the diagnosis sufficiently clear.

Prognosis.—Eustachian catarrh is ordinarily one of the simplest affections of the ear which it falls to our lot to meet. The only danger to the function of the organ lies in the tendency to a recurrence of attacks of this character. We have, then, to consider not only the outcome of the attack immediately under observation, but also the result if it is allowed to repeat itself at short intervals. An attack of Eustachian catarrh ordinarily yields to treatment in from five to fourteen days. The hearing is completely restored only at the end of several weeks, but if by complete restoration we mean an absolutely perfect functional condition of the organ in the ordinary acceptance of the term, the patient notices nothing abnormal about the ear, either as regards the integrity of hearing or the presence of subjective noises after a lapse of five to fourteen days. After an individual has suffered from several attacks of this affection it will be found that the hearing gradually becomes impaired, each exacerbation reducing it somewhat, at first imperceptibly, but later in the course of the disease to a degree distinctly recognizable both by the patient and by those with whom he is brought in contact in his daily vocation. This is caused by the development within the tympanic cavity of a slowly progressive inflammatory process, dependent upon the malposition of the contained parts for a long period of time. When the drum membrane is indrawn at frequent intervals by successive attacks of tubal stenosis, and remains in this position for a considerable period, it becomes stretched, and assumes an abnormal position more easily than does the normal membrane. The tendon of the tensor tympanic muscle from repeated relaxation becomes shortened, and exerts its influence in maintaining the irregularity of curvature which the membrane has assumed. This shortening of the tendon of the tensor causes the tip of the manubrium to press upon the internal tympanic wall. This source of mechanical irritation gives rise to an inflammatory process, ultimately resulting in the development of adhesions in other parts of the tympanic cavity, and producing a chronic catarrhal otitis media. Starting in this manner, we may have a simple hyperplastic process developed, or the condition so much dreaded by the otologist and laity—sclerosis within the tympanic cavity. While, therefore, a simple tubal catarrh, if left to itself, will in all probability disappear at the end of a certain interval, we should never lose sight of the danger of frequent recurrence, and it is our duty not only to relieve the single attack, but also to direct our efforts toward preventing a repetition.

Treatment.—The treatment of the affection will embrace measures directed to

First, the acute attack.

Second, prophylaxis.

When a patient suffers from the disease under consideration our first efforts are to relieve the subjective noises, the impairment of hearing and the feeling of discomfort within the ear, of which he complains. This is best accomplished by restoring the drum membrane to its normal position by some method of inflation. In adults there is no question but that the employment of the Eustachian catheter is the most effective means at our disposal. In children, the Eustachian tube being relatively short and catheterization being attended by considerable difficulty, resort may be had to inflation by the Politzer method. When the catheter is used we shall find, as a rule, that the mucous membrane of the nares and naso-pharynx is intensely tender, owing to the inflammation in this region which has caused the aural disease. To overcome this and to render the process of catheterization less disagreeable to the patient, a ten-per-cent solution of cocaine should be first sprayed into the anterior nares, the anæsthesia being completed by the passage of a cotton-tipped probe through the nares, the cotton having been saturated with cocaine solution. The catheter is then introduced in the ordinary manner, when, by compressing the inflating bulb several times, the membrane is replaced. Care should be exercised in performing this manipulation to compress the bulb gently at first, as suddenly filling the tympanic cavity with air at this period is liable to cause intense dizziness, and the patient may even fall in a dead faint. By performing the inflation slowly, and gradually increasing the force until the tube becomes permeable, this will be avoided. If the patient performs the act of deglutition at the moment the bulb is compressed, the air enters the cavity more easily. The relief is instantaneous when the malposition of the membrane is corrected, and the mental depression so common to these patients disappears at once. As the condition will undoubtedly return in from three to twenty-four hours after the first inflation, and from the sudden reappearance of the symptoms the individual may consider himself even worse than before treatment, it is always well to call attention to the probability of this recurrence. It is exceptional that a single inflation will permanently relieve the condition and the consequent symptoms. Sometimes the tube is so tightly closed that the air enters the middle ear only after repeated attempts at inflation. When this is the case the auscultation tube usually reveals the cause. This may be an œdema of the tubal walls, but more frequently is the lodgment of a plug of thick mucus in the tubal orifice, which completely prevents the entrance of air. This obstruction may be removed by wiping the tubal mouth with a pledget of cotton, the extremity of the cotton carrier being curved like the Eustachian catheter. After this has been done inflation becomes a very simple matter. The drum membrane being replaced, our next efforts should be directed to the abnormal condition within the tube. The site of the greatest œdema is usually the pharyngeal orifice, a part easily accessible to instruments introduced through the lower meatus of the nose. To control this œdema an astringent should be applied to the tubal mouth by means of a pledget of cotton, the cotton holder being bent in the form of the Eustachian catheter. None is better than a solution of nitrate of silver varying in strength from ten to thirty grains to the ounce. The degree of concentration suited to any particular case can be learned only by experiment, but in general the more acute the process the stronger the solution to be used. Concerning the application of vapors to the Eustachian tube, I do not believe this procedure to be wise in the early stages, as their action usually increases rather than diminishes the local congestion. The application of astringents seems not only more rational, but, clinically, is followed by better results. The operation of inflation and topical applications to the pharyngeal orifice of the tube should be repeated at first daily, and later, as improvement becomes more marked, the interval should be prolonged to several days, until complete restoration both of physical condition and of function takes place.

In some cases it will be impossible to open the Eustachian tube by any method of inflation. Here resort must be had to the Eustachian bougie. I am in the habit of using for this either the bougie catheter (shown in Fig. 93), the dilatation being effected by means of an olive-tipped metal bougie passed through the rings upon the back of the catheter, or, in the absence of this, the ordinary Eustachian catheter, through which a piece of No. 5 piano wire is passed. The extremity protruding from the catheter is roughened slightly with scissors and armed with a pledget of cotton, care being taken to wind this so firmly that it can not be displaced. The wire is then drawn into the catheter so that the cotton-tipped end alone protrudes. Remembering that the diameter of the Eustachian tube varies from three quarters of a millimetre to two millimetres, the size of this cotton pledget should certainly not exceed the last-named dimension, and when used for the first time it is well to make it considerably smaller than this. The opposite end of the wire is bent at a right angle at a point one inch and a half from the outer funnel-shaped extremity of the catheter. This, then, enables us to estimate the distance that the bougie has passed into the tube at any time. The bougie catheter or the ordinary Eustachian catheter armed in this way is introduced in precisely the same manner as in performing the operation of inflation, after which the catheter is firmly fixed in position by the fingers, and the piano wire is made slowly to advance in the direction of the Eustachian tube, the patient being requested to swallow at frequent intervals, both to relax the faucial muscles and to increase as much as possible the diameter of the canal. After the instrument has passed about an inch beyond the pharyngeal orifice it will apparently meet an obstruction which will be recognized as the isthmus of the canal, the region at which the lumen is normally less than in other locations; aside from this any obstruction encountered constitutes a pathological condition. In passing the instrument beyond such an obstruction the greatest gentleness must be employed, lest the mucous membrane of the canal be wounded and decidedly uncomfortable symptoms supervene. Most frequently in tubal catarrh

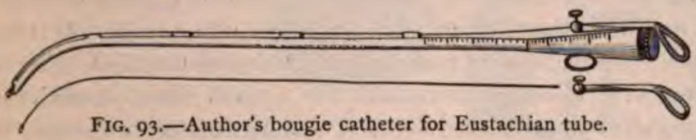


FIG. 93.—Author's bougie catheter for Eustachian tube.

the obstruction is confined to the cartilaginous portion of the tube, the osseous segment remaining free. The use of the cotton pledget as a dilator has a twofold advantage. In the first place, the metal parts of the apparatus may be sterilized in boiling water, and if the pledget is formed of sterilized cotton it is impossible to introduce any pathogenic bacteria during the operation. A pledget of cotton tightly twisted in this manner increases in volume when moistened. If, therefore, an obstruction is met with, and the instrument, after engaging it, is allowed to remain for a short time, considerable dilating force is exerted by the absorption of moisture, and a twofold advantage gained. Concerning the danger of the pledget of cotton becoming detached in the lumen of the tube, it can only be said that this has never occurred, and if ordinary care is used in the preparation of the apparatus no such accident can follow. The necessity of thoroughly boiling the instrument immediately before using it can not be too strongly emphasized.

Where the lining membrane resists these efforts the application of astringents to the mucous membrane beyond the orifice is indicated. These may be made by moistening the cotton pledget previous to its introduction with a solution of nitrate of silver of various strengths, beginning with a weak solution, about five to ten grains to the ounce, and gradually increasing the strength until the desired result is obtained. Under no condition should inflation be practiced immediately after the introduction of a bougie, since a slight abrasion of the mucous membrane may furnish an avenue of entrance to the air and submucous emphysema may result.

When the condition fails to improve at the end of ten days, stimulating applications in the form of vapors may be employed with advantage. The object of such applications is temporarily to increase local hyperæmia, and, by means of this increased blood supply, to restore the tone of the parts and cause them to resume their normal condition. It makes but little difference what vapor is employed, so long as we bear in mind the object to be attained. Any preparation which is a local stimulant and vaporizes at the ordinary temperature may be used. Tincture of benzoin, oil of eucalyptus, menthol, iodine, camphor, and various aromatic oils may all be used with success; the vapor of alcohol, of ether, or of chloroform is also efficacious. The best method of exhibition is by means of a device by which the current of air on its way to the tympanum is made to pass over the volatile substance, thus becoming charged with a certain amount of the volatile principle. Either Roosa's or Lucæ's bulb, or the bottle devised by Dayton, or the instrument of the author (Fig. 94), may be employed, according to the choice of the operator.

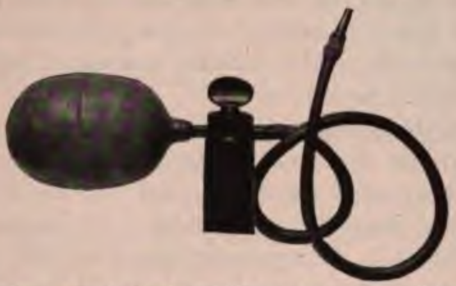


FIG. 94.—Author's middle-ear vaporizer. The reservoir is fitted with stop-cock, and either air or medicated vapor can be insufflated at will by turning this. When the thumb-screw lies in the long axis of the inflating tube, air alone passes through the catheter; when it is turned at right angles to this, medicated vapor is insufflated.

If the author's apparatus is employed, it is well, instead of filling the reservoir with the fluid, to place a little cotton saturated with the preparation to be used within this, as in the event of the accidental breaking of the reservoir by a sudden motion of the patient no damage is done to the garments either of the patient or of the physician.

My own preference when vapors are employed is first to clear the tube as perfectly as possible by inflating with air alone, after which the inflation is continued with the medicated air. The strength of the application varies with the nature of the substance and with the condition of the parts. The menthol and camphor may be used in alcoholic solution in the strength of one drachm of each to the ounce of alcohol, or the solvent may be tincture of iodine, if the stimulating effect of the iodine seems indicated. The other drugs mentioned should be used in the same relative proportions. A third local stimulant of considerable value is a mixture of the oil of eucalyptus and pine-needle oil in equal proportions. Oil of cloves may be used in strength of half a drachm to the ounce of alcohol. When iodine is used, the officinal tincture is the preparation best suited for the purpose. Ether and chloroform should be used in exceedingly small quantities, as they are extremely irritating, and their use is attended by considerable discomfort.

The advantages of inflating first with air and subsequently with a medicated vapor, instead of using the medicated air from the first, lie in the fact that by this means very little of the medicated air is brought in contact with the mucous membrane of the nose and naso-pharynx, and local irritation here is reduced to a minimum. When medicated vapors are used the catheter is always the instrument to be employed for their introduction if this is possible. Occasionally, however, we may be obliged to resort to the Politzer method of inflation; but if possible this should be avoided.

Under prophylactic measures must be included attention to the mucous membrane lining the nasal passages and the pharyngeal space. Inquiry into the history of these cases shows that the patients are subject to frequent "colds in the head or throat." If any departure from the normal condition is present in these regions it should be dealt with radically. The removal of enlarged faucial and pharyngeal tonsils, the reduction of a hypertrophic process within the nares, either by chromic acid, the galvano-cautery, or any other appropriate measure, and the actual removal of any obstructive deformity of the septum or of an extensive hypertrophy of turbinated bodies which has failed to respond to less radical measures, will be necessary in order to prevent repeated attacks of similar nature. When no deviation from the normal standard exists aside from the condition dependent upon the acute attack, the general hygiene of the patient must be investigated. The daily use of the cold bath, preferably of the plunge bath, is essential; but if this for any reason is contra-indicated, the cold sponge bath may be substituted. The use of all-wool underwear and a regulation of the habits of life will ordinarily enable us to prevent successive attacks.

Ordinarily the local treatment occupies the most prominent position in the mind of the physician; but it can not be too strongly urged that careful attention to the hygienic surroundings of the patient are of quite as much, and frequently of more, importance than the employment of the topical applications.

CHAPTER XVIII.

TUBO-TYMPANIC CONGESTION.—ACUTE TUBO-TYMPANITIS.—TUBO-TYMPANIC CATARRH.

IN this condition, in addition to the changes already mentioned as occurring in the Eustachian tube, there is present a congestion of the mucous membrane lining the middle ear, dependent upon the physical changes which the tubal occlusion causes rather than upon any actual inflammatory process within the tympanum.

Ætiology.—The same conditions which produce a tubal catarrh may cause the affection under consideration. The exact condition which results in any individual case depends both upon the activity of the exciting cause and upon conditions within the tympanum peculiar to the particular case. If the tympanic vessels are wanting in tone from some systemic condition, or have been in a state of engorgement for a considerable period from local causes, the sudden occlusion of the tubal lumen will effect certain changes within the middle ear recognizable upon physical examination, and active in the production of certain subjective symptoms. The exciting causes of the attack are usually the same as those of simple tubal catarrh, and their repetition here is unnecessary.

Pathology.—We may find within the tympanum a simple engorgement of the vessels supplying the mucous membrane, leading to a general hyperæmia of the inner tympanic wall and, to a lesser extent, of the drum membrane itself, this being most marked along the course of the vascular plexus. This congestion may result in two conditions—either one of hypersecretion with the accumulation of mucus within the tympanic cavity, or in a simple serous exudation due to the tenuity of the vessel walls. This condition of the vessels is usually of constitutional origin and is not uncommon in those affected with a gouty diathesis or with chronic cardiac, hepatic, or renal disease. In the membrana tympani this venous congestion is evidenced by an increased amount of blood within the veins. As the vascular network is most rich in the upper and posterior segment close to the periphery and along the manubrium mallei, these localities show, upon inspection, deviations from the normal color. It is true that stasis is the first stage of any inflammation, but the disease under consideration does not usually progress further than this first stage. The reduplications of mucous membrane in the upper part of the cavity may also be involved, the effused serum draining into the atrium or bulging the upper part of the membrane. Sometimes this bulging may be so great as to threaten spontaneous rupture, and it is then the duty of the surgeon to evacuate the fluid by incision before this rupture takes place. In cases of tubo-tympanic congestion, the fluid thus evacuated will be found to be entirely free from bacteria.

Symptomatology.—The symptoms already enumerated under tubal catarrh undergo slight modifications when the cavity of the middle ear is involved. Instead of the "stuffy" feeling so characteristic of Eustachian occlusion, these patients frequently complain of distinct pain in the ears, while the feeling of heaviness and numbness about the head is less marked. Pain is particularly well marked when the vault of the cavity is involved. The impairment of hearing is usually not as sudden, nor is it as pronounced as in simple occlusion of the tube. This may perhaps be explained upon the theory that the slight swelling of the membrana tympani renders its displacement by atmospheric pressure less easy, and consequently the ossicles are not crowded together as firmly as when no obstacle is offered to the displacement of the drum membrane. Tinnitus is present, and may be distressing; it is prone to be influenced by the position of the patient, and is most complained of when the horizontal position is assumed, as this posture increases the vascular engorgement. When there is fluid within the middle ear the sufferer frequently complains of great variations in hearing according to the position of the head. When sitting quietly he may be conscious of a slight impairment, but if the head is suddenly bent backward this impairment becomes marked, disappearing again when the erect position is resumed. The reason is that the effused fluid is capable of a certain amount of motion within the middle ear, and when the head is bent backward flows to the postero-inferior part of the cavity, covering the round and oval windows and interposing an obstacle to the entrance of sound waves. Owing to the presence of fluid within the tympanum, vertigo is not an uncommon symptom in these cases. The vertiginous attacks are usually induced by such changes in the position of the head as will cause the fluid to flow back over the regions of the oval and round windows. With the head in the erect position, the patient will not suffer with the vertigo. When, however, the head is thrown backward or to one side, the dizziness may be very severe.

Another quite characteristic symptom is the occurrence of a bubbling or snapping sound when the patient blows the nose forcibly, or sometimes during the act of deglutition. During the performance of these acts the tubal obstruction momentarily becomes less complete, and the current of air entering the tympanum passes through the fluid and gives rise to the sound.

Autophony is also frequently complained of, while subjective noises may vary considerably according to the position of the head, being usually more severe in the recumbent position. A condition of hyperæsthesia of the auditory nerve may occur in these cases, causing certain sounds to be painful. The sounds producing a painful impression are high-pitched, but ordinarily not those of the highest pitch, since the occlusion of the niche of the round window by the fluid lowers the upper tone limit of sound perception considerably.

When the ear has been inflated by the patient himself, either accidentally or by design, the hearing immediately improves to a surprising degree, while the retrograde change may be equally sudden after the act of deglutition.

Diagnosis.—A. *Physical Examination.*—The inspection of the parts by means of reflected light will reveal appearances which vary considerably in the different cases according to the actual conditions present. The distinctive feature, as contrasted with a simple tubal stenosis, lies in the fact that the drum membrane or the internal tympanic wall shows evidences of circulatory changes, which are absent when the tube alone is affected. The position of the drum membrane is usually that of moderate retraction, the extent of this not being as great as when the tube alone is affected. The membrana tympani varies slightly from the normal color; instead of being pearly white, it is changed to either a dull white throughout, or it is of a light pinkish-white tinge. At the periphery and along the handle of the malleus the change of color is decidedly more marked and is of a dull-reddish hue. These changes in color along the manubrium and at the periphery do not indicate a true inflammatory condition, but a venous congestion simply, with a consequent prominence of the veins forming the manubrial and peripheral plexus. This dull-reddish color is sometimes very prominent above the short process from the congestion within the tympanic vault and is indicative of the possibility of the process, progressing to suppuration. The pinkish tinge of the entire membrane which we sometimes observe is due not to changes in the membrana tympani itself, but to congestion of the internal tympanic wall. The rays of light pass through the membrana tympani and illuminate the internal wall of the middle ear, which is in these cases considerably reddened. This colored background gives to the membrana tympani the pinkish tinge described, but the change in color depends upon congestion within the cavity rather than upon any changes within the membrana tympani itself aside from those already mentioned as occurring in the venous plexus of the membrane.

The malleus handle appears foreshortened according to the degree of collapse, but seldom to the extent seen in simple Eustachian occlusion; the anterior and posterior folds are more prominent than normal; from stasis the membrane may appear thicker than normal, and may partially lose its lustre. On account of the displacement, the light reflex is changed both in position and shape, and may be multiple. These changes are recognized ordinarily when no effusion has taken place within the tympanic cavity. If, owing to the abnormal fullness of the vessels, a certain amount of transudation has taken place within the tympanum, the degree of depression is not apt to be as marked. Instead of this, a close inspection will reveal the membrana tympani, presenting in its inferior segment a slightly yellowish color, the lustre of the membrane being diminished, while the density is increased. This dull look is wanting in the upper part of the membrane, the illuminating rays penetrating it and revealing more or less distinctly the condition of the inner tympanic wall; and if the membrana tympani is thin, frequently enabling the observer to recognize the long process of the incus on the posterior crus of the stapes (Fig. 95). The appearance is due to a collection of fluid in the lower part of the tympanic cavity, the result of serous transudation. Not infrequently we observe the line of demarcation between the upper and lower areas as sharp and distinct, appearing as a fine line which traverses the membrana tympani transversely (see colored plates). This line marks the level of the fluid in the tympanic cavity, and may be mistaken for a hair stretching across the surface of the drum membrane. By tilting the head of the patient forward or backward, it is often possible to observe changes in the direction of the fluid line. If the patient practices auto-inflation, the current of air upon entering the tympanic cavity will bubble up through the contained fluid, and upon inspection these bubbles are visible (Fig. 96); they change their position when the patient swallows or forces more air into the tympanic cavity. Naturally their presence is an unquestionable evidence of fluid. In cases where the drum membrane has been thickened from preceding inflammation it may be so dense as to prevent the recognition of these air bubbles upon ocular inspection. In such instances several bright points of light are often seen upon the surface of the membrane below the level of the fluid. These multiple reflexes are indicative of the presence of fluid, although they must not be relied upon as absolutely characteristic of this condition. Inflation with the catheter or by Politzer's method will reveal, through the diagnosis tube, the characteristic bubbling as soon as the air enters the middle ear. When serum alone is present the râles produced by the bursting of the bubbles will be sharp and high-pitched; when a certain amount of mucus is mixed with the serum, the sound will be of lower pitch and of less intensity and the explosive sounds will follow each other at less frequent intervals. The absense of râles upon auscultation can not be taken as a positive evidence that no fluid is present in the middle ear. A small amount of effusion may lie entirely out of the air current and give no sign of its presence. Again, the fluid may be incapsulated in a fold of the mucous membrane, and thus be unaffected by the operation of inflation.

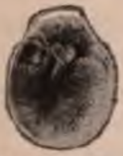


FIG. 95.—Moderate retraction of membrana tympani. Incudo-stapedial articulation visible in upper posterior quadrant.

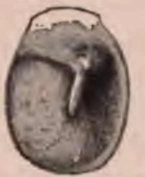


FIG. 96.—Posterior segment of membrana tympani bulged by fluid in the tympanum. Bubbles of air in the fluid are visible through the membrane.

B. *Functional Examination.*—Upon examining the patient with reference to the power of audition we shall find diminished air conduction, both for sharp sounds—such as the watch and acoumeter—and for the conversational voice and whispered speech, the defect for the vocal sounds being relatively more marked than for isolated sharp sounds. The tuning fork will show an elevation of the lower tone limit, while the Galton whistle indicates a reduction of the upper tone limit. This latter will be more marked when fluid is present and occupies such a position as to cover the round and oval windows. The vibrating tuning fork, placed upon the forehead, is usually lateralized to the more affected side in cases of bilateral disease, or toward the affected side when only one ear is involved. Absolute bone conduction for a fork of two hundred and fifty-six or five hundred and twelve double vibrations per second is usually increased, although sometimes it may be slightly less than normal. While this latter condition indicates the involvement of the perceptive apparatus, the labyrinthine lesion depends upon the process within the middle ear, and will disappear when the tympanic condition becomes normal. The presence of fluid in the middle ear may modify the results of the functional tests, and render an exact diagnosis of the condition of the perceptive apparatus impossible until it has been removed by therapeutic or surgical measures and the conducting mechanism has been restored as nearly as possible to its normal condition.

Prognosis.—In many of these cases, especially in children, the parts return to a completely normal condition without treatment. In adults, while spontaneous recovery occurs in a certain proportion of instances, it is probable that the function of the organ is not completely restored. Aside from spontaneous resolution, we may have developed, as a result of this process, a chronic otitis media, the persistent congestion of the parts ultimately resulting in an inflammatory process of the chronic type. This may result either in an hypertrophy of the mucous membrane lining the cavity, the reduplications increasing in number and in density, or occasionally we have developed a true hyperplastic inflammation, in which the connective-tissue framework of the lining membrane of the middle ear becomes firm, the interfibrillary substance being absorbed, and a sclerotic condition is the result. This process is usually more pronounced in the region of the oval and round windows than elsewhere. The membrane of the Eustachian tube may undergo similar changes. When the hypertrophic changes occur within the tympanum the Eustachian tube is also affected, its calibre being so narrowed that ventilation of the tympanum is interfered with. In the hyperplastic or sclerotic inflammation the result is to increase its calibre rather than to diminish it. In those cases where the circulatory system is impaired from diathetic causes, the effusion in the tympanic cavity may increase in amount when the mucous membrane of the upper air passages is congested as the result of exposure to cold or of some disturbance of the primæ viæ, diminishing in quantity or disappearing when the patient is in a fairly normal condition.

Treatment.—In the acute stage the measures already mentioned under the treatment of tubal catarrh are to be adopted. Proper attention to clothing and hygienic surroundings and the treatment of the upper air passages, surgically or otherwise, is of the greatest importance in preventing recurrent attacks.

In addition to this we have to deal with the congestion within the tympanum itself, and when effusion is present our treatment must be of such character as to produce either its absorption or its exit by mechanical means. For the relief of the venous engorgement local bloodletting stands pre-eminent. The abstraction of from two to four ounces of blood from the region immediately in front of the tragus is frequently followed by a complete cessation of the unpleasant symptoms and restoration of function. When seen early, this method may prevent the effusion of fluid into the middle ear. Next we should try to prevent this transudation by restoring the intratympanic pressure as nearly as possible to its normal standard. This is to be effected by inflation of the middle ear, either by the Politzer method or by the use of the Eustachian catheter. Authorities vary considerably as to the propriety of using the air douche in acute congestion of the tympanum. To my mind, there is no question but that inflation is beneficial in a very large proportion of these cases, and frequently shortens the duration of the disease, preventing transudation of serum by supporting the intratympanic vessels. The relief to the subjective symptoms is also very marked, and in no instance have I seen the condition aggravated by the operation, even when relief did not follow. After the effusion of serum has taken place, local bloodletting is ordinarily useless unless actual pain is present, and we have reason to fear that the process may become inflammatory.

After effusion has taken place our efforts should be directed toward its removal. Two ways are available: either evacuation by incision through the drum membrane, or removal through the Eustachian tube. The objection to early incision of the membrana tympani is the supposed tendency to recurrence when the fluid is evacuated in this manner. Unless the transudation is considerable in amount and causes much discomfort, it is well to attempt its absorption, reserving incision of the drum membrane for persistent cases only. The prime factor influencing the absorption of the fluid is a patulous condition of the Eustachian tube, thus relieving the venous turgescence and permitting the passage of the effusion into the lymphatics. The restoration of the tube to a patulous condition is effected by the use of the catheter, the bougie, the application of astringents to the orifice of the tube, or inflation with medicated vapors. These measures have been detailed under tubal catarrh. When the condition has existed for a considerable time the mucous membrane of the middle ear may not readily take up the fluid. Here inflation with any medicated vapor which will stimulate the lining membrane may accomplish the desired object. For this purpose we may use menthol or camphor in the proportion of one drachm to an ounce of alcohol, the vapor of the oil of eucalyptus in full strength, or even alcohol vapor alone. It is best, when the fluid is not too viscid, to evacuate a certain amount of it through the Eustachian tube by means of the air douche. To do this the head should be inclined forward and toward the unaffected side during the performance of the operation, and occasional attempts at deglutition should be made, as this act renders the tube more patulous and permits the fluid to be displaced more easily. An effusion of this character should yield to treatment in not less than fourteen days, the air douche being administered at first daily, and, as the condition improves, at longer intervals. If a decided impression has not been made upon the fluid at the end of this time it is unwise to delay longer, and the membrana tympani should be incised. The same plan should be adopted even at an earlier period if the patient can not be kept under observation sufficiently long to insure a complete restoration by the milder measures already indicated. Considerable difference of opinion exists as to the precise location and the extent of incision through the drum membrane. To my mind the question should be decided on general surgical principles. The object sought is perfect drainage and a rapid and perfect restoration of the parts to their normal condition. These ends can be attained only by a free and extensive incision which will evacuate all the fluid and leave the parts in a condition favorable to immediate union throughout the entire line of section. In order that the drainage may be perfect, the lowest point of the opening must lie near the inferior pole of the drum membrane. Since the upper and posterior part of the cavity is the most capacious, an effusion sufficient in amount to demand evacuation usually causes a bulging of the drum membrane in this locality. I prefer, therefore, to insert an exceedingly sharp but delicate knife close to the periphery of the membrana at a point opposite the short process; the knife is then carried downward close to the periphery to the lowest point of attachment of the membrana tympani. The section lies entirely within the clear membrane, and should not wound the cartilaginous ring. When considerable congestion is present it is advisable to secure local depletion by carrying the knife sufficiently inward to make it impinge upon the internal tympanic wall so as to divide the soft parts which cover it, throughout the entire extent of the incision through the drum membrane. If the parts above the short process are intensely congested the incision is to be extended upward so as to enter the vault and deplete the engorged tissues. In these cases it is usual to incise from below upward (Fig. 97). A few vigorous efforts at inflation by means of the Politzer method clears the cavity completely of fluid, the divided parts fall readily into place, approximation being practically perfect, and it is not unusual to find complete union at the end of thirty-six hours. The only possible untoward result following this pro-

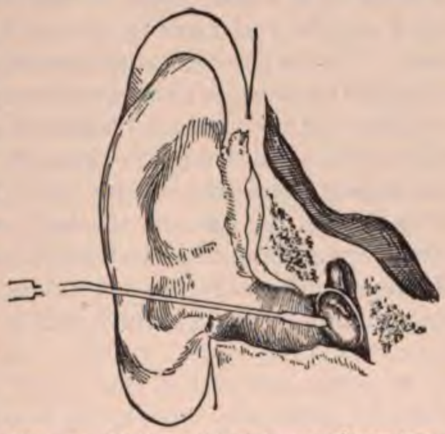


FIG. 97.—Method of incising membrana tympani to evacuate fluid in the atrium (natural size).

cedure is accidental infection at the time of the operation. To avoid this the canal should be first syringed with a solution of bichloride of mercury (1 to 8,000), while the instruments employed should be sterilized by boiling. After the fluid has been evacuated the canal should be closed by a plug of aseptic cotton and the patient should on no condition interfere with it. Carried out in this manner, there is absolutely no danger in adopting this method of treatment for an effusion of any kind within the tympanic cavity. In nervous patients it is well to perform the operation under nitrous oxide anæsthesia.

Nothing has been said concerning the administration of internal remedies. I have little faith in the beneficial action of any drug for the correction of the condition under consideration. As a prophylactic measure it is well, upon the disappearance of the attack, to guard against recurrence by the exhibition of drugs supposed to be particularly efficient in overcoming a lymphatic diathesis. This is especially true in the case of children. The administration of the iodide of iron in doses of four to eight grains three times daily, together with hypophosphites, will do much in the direction of causing a spontaneous disappearance of the deposits of lymphatic tissue in the naso-pharynx and pharynx. Often after surgical interference, it is well to employ these remedial agents for a period of a month or six weeks to insure the permanency of the result. Where the condition depends upon a disturbance of the vascular apparatus, as in arterio-capillary sclerosis, or upon a renal lesion, the proper treatment of the general disease may do much to diminish the local process. The application of astringent remedies to the tympanic cavity, either through the Eustachian tube or through an artificial opening in the drum membrane, is not, I think, indicated in this condition, since we are dealing not with an inflammation, but with an obstruction to the venous flow.

CHAPTER XIX.

ACUTE CATARRHAL OTITIS MEDIA.

This term is applied to an actual inflammatory condition within the middle ear, resulting in an increase in the normal secretion. In this way it differs from the process just described. Why in one patient we should have a simple congestion of the tympanic lining, and in another an acute inflammatory process, the factors of causation being similar in the two cases, it is impossible to state. It seems that the difference must depend somewhat upon the power possessed by the individual to resist the invasion of pathogenic bacteria and also upon the virulence or degree of infection in the individual case. It is certain that venous stasis plays a part in the causation, as in this condition any membrane is particularly susceptible to the absorption of bacteria. The infection, then, of an individual in perfect health might result in the first stage of inflammation simply or an obstruction to the venous flow with possible effusion of serum from mechanical causes alone. In an individual less robust the infective process would be carried one step farther, and we should have, following the stage of congestion, an actual inflammatory process developed. Here again comes the question as to why in certain instances this inflammatory process results in the formation of mucous secretion, and in others in the formation of pus. We have in the structure of the middle ear a sufficiently clear explanation of this, I think. Remembering that the upper part of the cavity contains a large amount of connective tissue, we should expect infection in this region to be followed by an inflammation of the cellular type, while infection of the lower portion of the cavity would result in a simple catarrhal inflammation of the lining mucous membrane. Clinical experience bears out this theory. It is this last-named process that occupies our attention at present.

Ætiology.—An acute catarrhal otitis may complicate measles or a cold in the head, or may be caused by the introduction of fluids into the middle ear through the Eustachian tube while bathing, or through the use of the nasal douche. Violent efforts at clearing the nostrils may occasionally cause the affection in the same manner. Any abnormal condition of the upper air passages, particularly the presence of an enlarged pharyngeal tonsil, predisposes to this disease. Exposure to cold or wet may bring on an attack without any other symptoms referable to the upper air tract being present. Traumatic rupture of the membrana tympani may lead to an infection of the atrium and a simple inflammation of its lining membrane, although in most cases of these instances the inflammation is purulent in character.

Pathology.—The pathological changes have been described in what has already gone before. The inflammation is confined to the superficial layer of the lining membrane of the tympanum, the basement membrane escaping. Most frequently only the lower part of the tympanic cavity is involved. The reduplications lying within the vault are congested and swollen, but the process does not go farther than this. As the result of the inflammation the action of the mucous glands is stimulated, and their secretion, mixed with the transuded serum, fills the tympanic cavity with a turbid fluid, rather thick in consistence and containing much mucin and holding in suspension desquamated epithelial cells. The changes involve the mucous layer of the membrana tympani, which becomes swollen and, by exfoliation of its superficial cells, leaves the fibrous layer exposed; this becomes infiltrated also, and from the pressure of the accumulated secretion may give way at one point, permitting the pent-up fluid to flow into the canal. Spontaneous perforation in these cases probably depends as much upon the increased pressure as upon the actual inflammatory process involving the deeper layers of the drum membrane. The Eustachian tube, while partaking of these pathological changes to a certain degree, is not involved to the same extent as in a simple salpingitis, the activity being more directed toward the lining membrane of the middle ear.

In recent years much attention has been paid to the determination of the various forms of bacteria which may be present in aural discharge. In the disease under consideration, the micro-organisms will vary according to the predisposing cause of the aural affection. The severity of the attack will also depend largely upon the character of the micro-organism which has induced the disease. In the milder cases we find a staphylococcus or diplococcus infection. In the severer cases, we have a streptococcus infection. In certain cases, complicating epidemic influenza, the specific influenza bacillus has been found.

Symptomatology.—The symptoms vary considerably, according to the age of the patient. For convenience we will consider the disease first as affecting adults, and later as affecting children.

A. *In Adults.*—The early symptoms may be so slight as to pass unnoticed. They consist in a feeling of fullness and stuffiness in the ear, dependent upon the occlusion of the Eustachian canal. This sensation is soon followed by pain in the ear referred to the tympanic cavity, and of steadily increasing severity. The degree of pain is ordinarily sufficiently acute to prevent sleep, provided the attack occurs at night. The pain is usually distinctly localized, and seldom partakes of the diffuse character found in inflammation of the external meatus, while its severity enables it to be distinguished from that due to closure of the Eustachian tube. The pain is usually most severe upon lying down, owing to the determination of blood to the head when this position is assumed. Subjective noises of high-pitched character manifest themselves quite early, but are not complained of, on account of the severity of the pain. Impairment of hearing is at first slight, but steadily increases, and may reach an exceptionally high degree. When the stage of hypersecretion is reached the pain subsides gradually, being replaced by a feeling of fullness or heaviness in the side of the head. Each act of deglutition is painful, and the patient is conscious at these times of the entrance of air into the tympanum, its passage through the fluid producing bubbling sounds, while the movement which it causes in the intratympanic structures is attended by lancinating pain on account of the swollen condition. The body temperature may be slightly elevated, and from the severity of the pain some prostration may follow. At any period varying from twelve to forty-eight hours spontaneous rupture of the membrana tympani may take place, as evidenced by the appearance of a sero-mucous discharge from the external auditory meatus, and an abrupt cessation of the pain. In many cases rupture does not take place, and the disease, having run its course, leaves within the tympanic cavity a collection of sero-mucus, which then produces the characteristic symptoms of an intratympanic effusion. If the drum membrane is exceedingly dense and does not yield to the pressure of the fluid, the vault of the tympanum may become involved secondarily, and a purulent inflammation supervene. In still other instances, where no spontaneous outlet is effected, the lining membrane of the mastoid cells becomes involved. The patient complains of severe pain behind the ear, gradually spreading to the side of the head. This involvement is usually associated with an elevation in body temperature and an increase in the severity of all the symptoms.

The discharge may cease spontaneously at the end of a few hours or days. It may continue as a sero-mucous discharge, or by exposure to the air it may become infected, its character then changing to a purulent secretion. When this occurs, the infection may spread to the middle ear, involving the structures situated within the vault, and may then follow the ordinary course of a chronic purulent inflammation of the middle ear. In other cases the discharge of the fluid is followed by a complete cessation of all symptoms, the opening of the membrana tympani closing spontaneously and the parts returning to their normal condition.

B. *In Children.*—In very young children the symptoms characteristic of an acute catarrhal inflammation of the middle ear may be of so severe a type as to incline one to the opinion that the child is suffering from a much graver disease. The attack usually comes on at night. The infant at first tosses about in bed and throws the arms upward over the head, usually toward the affected side, although this is not invariable. After a short period of disturbed sleep the child wakens and gives evidence of intense suffering. The temperature is frequently exceedingly high, and may reach 106°, but usually varies from 102° to 104°. The rise in temperature may be the only symptom, and therefore, one may remain in complete ignorance of the cause of this rise in temperature until, after several hours, a sero-mucous discharge appears in the meatus. This is usually accompanied by a cessation of all symptoms, the child dropping off to sleep and the temperature gradually falling. In certain cases the attack may be ushered in by repeated convulsions and by vomiting, simulating very closely an attack of meningitis. With the appearance of discharge from the ear, pain usually ceases, and in many cases the temperature becomes perfectly normal. This is not the invariable rule, however, even though drainage is free. The drum membrane of a child is exceedingly thin and yields easily to the outward pressure of the fluid, rupturing before the inflammation within the tympanic cavity has ceased. An elevation of the temperature, therefore, may continue for a few days after perfectly free drainage is secured. When this is the case the temperature is apt to be either remittent or intermittent, the elevation in the afternoon reaching 103° or 104° in many cases.

The character of the discharge both in adults and children varies acording to the period of the disease. During the first few days the fluid is large in amount, turbid from the mixture of epithelial cells, and rather viscid in consistence from the presence of mucin. The viscidity of the discharge offers an obstruction to its free exit through the small opening in the drum membrane and obstructive symptoms may occur. As a rule the discharge is much more profuse in children than in adults and contains a greater number of epithelial cells. When the case progresses favorably the secretion gradually diminishes in amount, becomes thinner and more watery, and finally disappears entirely. If proper attention is not paid to cleanliness the fluid may become infected in the auditory canal, the infection may spread to the tympanic cavity, and a purulent otitis media supervene from inoculation of the connective-tissue structures in the tympanic vault. This accident need never happen if proper attention is paid to cleanliness. The presence of the secretion in the meatus tends to soften and remove the epithelial matter, thus leaving a denuded surface, through which infection may take place and localized or diffuse otitis externa follow.

After the appearance of the discharge the constitutional symptoms may again become severe if the opening through the drum membrane becomes occluded either by thick mucus or as the result of the reparative process; especially is this true when a case progresses rapidly toward recovery and an acute naso-pharyngitis occurs as the result of exposure to cold. From this cause the inflammatory process within the middle ear becomes augmented and a sudden increase in the amount of secretion takes place. The opening through the drum membrane is not of sufficient size to permit of free drainage, and the symptoms already described in the earlier part of the chapter are repeated. A relapse of this character is always to be feared, since there is danger of secondary inflammation of the mastoid cells. Occlusion of the opening in the membrana tympani, even for a short time, may also result in mastoid involvement by any fresh access of inflammatory process.

The impairment of hearing and the subjective noises usually diminish after the pressure within the tympanum is relieved by the passage of the contained fluid into the auditory meatus. Necrosis of the osseous tympanic wall or of the ossicula themselves does not take place in simple catarrhal otitis, although the condition is frequent in the purulent variety. These sequelæ will be considered under a chapter on purulent otitis media.

Diagnosis.—A. *Physical Examination.*—An inspection of the canal and membrana tympani in the early stages will reveal a distinctly hyperæmic condition of the drum membrane, most marked in the region of the manubrium, the redness shading off gradually into the normal color of the part. The structures above the short process—that is, in Shrapnell's membrane—may also present a reddish color quite early in the disease, since the blood vessels of the membrana tympani are richly distributed in this region and venous congestion may be marked. The hyperæmia is distinguishable from the vascular congestion present in tubo-tympanitis from the fact that the vessels themselves do not stand out prominently, but the redness is diffuse, merging gradually into the normal pearly white color of the membrana tympani, while in tubo-tympanitis the outline of the vessels is distinctly marked and there is a line of demarcation between the hyperæmic areas which are identical with the normal vascular plexus and the remainder of the membrane. The position of the drum membrane may be normal, although quite frequently it is moderately depressed; extensive collapse of the part upon the internal tympanic wall does not occur as a rule. At a later period the entire membrana tympani, particularly the membrana vibrans, is uniformly reddened; the lustre is wanting; the landmarks may be obscured on account of œdema; the short process of the malleus, however, is seldom completely hidden, even in severe cases, if careful search is made for it. At this period effusion has usually taken place, the result being to force the drum membrane outward into the canal. The displacement is usually most marked in the upper and posterior part (Fig. 98); in children, and in adults where the membrana tympani is more obliquely placed than usual, the membrana seems to be continuous with the postero-superior wall of the meatus, narrowing the fundus of the auditory canal, this region being converted into a small quadrangular area of not more than one quarter the normal size (Fig. 87). Such a narrowing is quite as characteristic of bulging of the drum membrane as a distinct globular mass filling the fundus of the canal. A point to be remembered in this connection is that the entire membrana tympani bulges as a whole, the change in position not being limited to the membrana flaccida. This is of considerable diagnostic importance when we remember that inflammations of a purulent character usually involve the upper portion of the cavity first, and the presence of fluid causes a protrusion of the membrana tympani above the short process of the malleus. More attention will be paid to this in a later chapter.

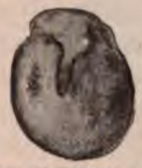


FIG. 98.—Moderate bulging of entire membrana tympani.

After the discharge has made its appearance, an inspection of the ear will reveal the canal filled with sero-mucous fluid. Upon removing this, the surface of the drum membrane will be seen covered with a dense white lustreless coating. This is due to a necrosis of the superficial epithelial layer, and may be easily removed by means of the cotton pledget, when the external surface of the membrana tympani will be seen to be red and swollen. The point of rupture should be searched for carefully, but where the canal is swollen it is sometimes difficult to locate it exactly. Usually it is found in the inferior segment, either just below the manubrium or in the anterior portion close to the periphery of the drum membrane. When examined immediately after rupture has taken place, the discharge pours out so rapidly that it is difficult to determine exactly the location of the opening. Nor is this of importance, provided we ascertain that it is of sufficient size to admit of free drainage. The presence of a muco-serous discharge in the canal is sufficient evidence that perforation has taken place. The use of the Politzer air bag or of the Eustachian catheter will, when the ear is inflated, afford us a certain evidence of this from the sharp, high-pitched perforation whistle. This sound is modified by the passage of the current through the fluid. Before perforation has taken place inflation gives simply the sounds characteristic of fluid within the tympanum.

In children we are not uncommonly called upon for an opinion immediately following an attack of "earache." From the history, we learn that the morning following an attack a slight amount of moisture was present upon the pillow, and that the margin of the orifice of the meatus was coated with a yellowish incrustation. At the time of our examination no discharge is present in the canal, the only symptom from which the child is suffering being an elevated temperature. Inspection reveals congestion of the entire membrana, while at one point we are able to make out a localized hæmorrhagic deposit. The signification of this appearance is that the attack was of only slight severity, and that spontaneous rupture occurred. The pressure was relieved by this means of exit to the effusion, and the minute opening has already closed. Our efforts here are confined to the prevention of subsequent attacks, as the immediate condition is undergoing spontaneous resolution.

B. *Functional Examination.*—Ordinarily the pain is so great in these cases that the functional examination is seldom made. We shall find, however, that the tuning fork placed in the median line of the skull will be referred to the affected side; air conduction for the lower portion of the scale will be wanting or much diminished. The upper tone limit may be normal or slightly reduced, and absolute bone conduction will be increased. The power of audition, both for speech and for sharp sounds, will also be much reduced.

Prognosis.—These cases terminate favorably, as a rule, often without treatment. Purulent otitis media and involvement of the mastoid cells occasionally occur. The latter condition may supervene whether perforation takes place or not.

If perforation does not take place, the case may fail to undergo complete resolution, and a certain amount of fluid may remain in the tympanum, causing impaired hearing and a persistence of subjective noises. If the fluid is absorbed, the mucous membrane may fail to return to its normal condition and become the seat of a chronic inflammatory process either of an hypertrophic or proliferative type. From the long-continued presence of fluid within the tympanum the drum membrane may become relaxed, and after the fluid has disappeared this change of tension may give rise to subjective noise, and to an impairment of audition from the ease with which it is depressed when the atmospheric pressure within the middle ear is diminished.

When perforation has taken place, the opening may close spontaneously; or it may persist, leaving the internal wall of the tympanum exposed; or the ligamentous structures within the middle ear may undergo cicatricial contraction, displacing the parts and interfering seriously with their function. This latter condition usually results when the inflammation becomes purulent in character. In a certain proportion of cases a simple catarrhal inflammation of the lower portion of the tympanum becomes purulent from infection through the Eustachian canal before the perforation takes place. This is particularly prone to occur when the process is active and the parts within the tympanic vault are excessively hyperæmic; the disease then follows the same course as acute purulent otitis.

The prognosis of the case is somewhat influenced by the bacteriological investigation of the discharge. In cases of simple catarrhal inflammation, involving the lower portion of the tympanic cavity, any micro-organism may act as the exciting cause of the disease. In those cases where the inflammation is confined to the lower portion of the middle ear, the micro-organism is one of low vitality. Those cases where the disease extends upward, involving the connective-tissue structures from the tympanic vault, however, represent a type of infection of exceeding virulence. In order that the surgeon may judge somewhat as to the further progress of the case, it is always wise, when spontaneous rupture of the drum membrane occurs, to make a bacteriological examination of the discharge, and in cases where the pain is severe and where rupture does not take place at an early stage, it is even wise to incise the drum membrane, and examine the secretion evacuated by incision in order to gain some idea of the character of the infection. In the mild cases we usually find a staphylococcus infection present, or one of the less active forms of bacteria. In those cases where the clinical history shows the disease has been very active, where the pain has been severe, the temperature high, and the local manifestations have appeared within the course of a few hours, we frequently find that we have to deal with a streptococcus infection, or we may have one of the various forms of diplococcus infection, such as diplococcus pneumoniæ. Where the infection is due to streptococcus or pneumococcus, a rather guarded prognosis as to the involvement of the adjacent structures should be given. In cases of staphylococcus infection, the patient may be reasonably assured that the disease will terminate favorably, without involvement of the adjacent bony parts.

Serious inflammation of the intracranial structures probably never occurs when the disease is of a catarrhal type. In children, where the tympanic roof is exceedingly thin, it is not improbable that meninges in the immediate neighborhood are congested; but the process stops here, and a true meningitis is not developed.

Treatment.—The first indication is the relief of pain. The patient should be put to bed, and a saline cathartic administered. While in the very early stages of the disease the administration of either opium or morphine, internally or hypodermatically, may be permissible, experience has taught me that this plan of treatment is unwise and should not be employed except in rare instances. Local bloodletting may be employed either by means of the artificial or natural leech, the blood being abstracted from the region immediately in front of the tragus. Personally, a rather large experience has convinced me that local bloodletting is of little value in these cases. It may, however, be employed, and perhaps in certain cases may be justifiable. In my own practice, however, I have never seen any good results follow this measure, and I have entirely abandoned its use.

The application of dry heat is certainly of value in relieving pain, and does not interfere with measures directed toward aborting the attack. The most convenient means of applying this is by means of a hot-water bag or Japanese pocket stove. Moist heat is objectionable, since it favors venous congestion, softens the tissues, and hastens local necrosis, rather aiding the development of the process we desire to abort. Theoretically cold applications would be of benefit; but the presence of any fluid of low temperature within the external auditory canal is painful under ordinary circumstances, and when the parts are acutely inflamed it is unbearable.

It is decidedly unwise to instill any oily solutions into the canal for the relief of pain. This practice is very common, and only serves to obscure the parts when an examination is made, and possesses absolutely no therapeutic value. A solution of carbolic acid in glycerin, in the proportion of one to twenty, is sometimes of service, and there is no objection to its use. The same may be said of aqueous solutions of morphine, atropine, and cocaine. The relief obtained is usually temporary, and we simply prolong the duration of the disease by their use.

Failing to abort the attack, and the pain continuing, we should not delay incision of the membrana tympani. It is of great importance, I believe, to perform this operation early, and not to wait until it is evident that spontaneous rupture will take place unless the fluid is evacuated artificially. The local depletion secured by the operation is of great value, while the relief to pain is usually immediate and permanent. If, then, at the end of twelve hours, the patient still complains of pain, the membrana tympani should be freely incised. When distinctly bulging, the centre of the incision should be over the most prominent point; but in the absence of any particular sign to guide us, the knife should be entered close to the periphery of the membrana tympani, just below the posterior fold, and the membrana completely divided by a curved incision downward to its inferior pole, the incision lying entirely within the clear membrane and parallel to its line of insertion. It is also wise to incise at the same time the membrane of the internal tympanic wall to secure additional depletion. This procedure is of value even when but a small amount of transudation has occurred. The operator should be exceedingly careful to use a knife which will pass through the membrane by its own weight, under which circumstances scarcely any pain is experienced. Attempts to anæsthetize the membrana tympani by a strong solution of cocaine scarcely diminish the pain instant upon the operation. In infants chloroform is the ideal anæsthetic, while in older children and in adults nitrous oxide should be used.

Before operating the field should be rendered aseptic in the manner already described in the consideration of the similar operation in the chapter on tubo-tympanitis. After the membrana has been divided, irrigation with a warm antiseptic solution relieves whatever pain may be present, and aids the divided vessels to return to their normal calibre. If section is performed early we may cut short the attack, the incision closing at the end of thirty-six or forty-eight hours, and the symptoms subsiding completely. When the operation has been postponed until the process is well advanced, the discharge ordinarily continues for a period of two to ten days, and may be quite profuse at first. During the period of discharge which may follow either spontaneous rupture or evacuation by surgical interference, the canal must be kept thoroughly cleansed. This end is best attained by the frequent use of the ear syringe in the hands of an attendant. The cleansing fluid may be either water which has been boiled and allowed to cool until it can be tolerated by the patient, or a mild antiseptic solution may be used. The frequency with which irrigation may be performed will depend upon the amount of discharge. At first the ear may require cleansing six times daily; the interval is gradually prolonged as the discharge becomes less viscid and diminished in quantity. It is important that these cases should be seen at first daily by the surgeon himself, at which time any fluid within the tympanic cavity should be thoroughly evacuated by the use of the air douche, the parts being afterward dried with absorbent cotton. It has been my practice, where I have been able to observe the case daily, to insufflate a small amount of boric acid into the canal after cleansing, thus securing a permanently aseptic condition of the parts, and guarding against carelessness on the part of the attendant, which might result in infection. Under no condition is a large amount of powder to be introduced into the ear, and unless the ear is inspected daily it should be a cardinal rule that no powders are to be used. When the discharge has nearly ceased, and is so small in amount that it does not appear in the external meatus when the ear is left undisturbed for twenty-four hours, more prompt recovery takes place if fluid applications are discontinued entirely, the discharge being removed by absorbent cotton, after which a small amount of boric acid is dusted over the parts. This suffices to preserve an aseptic condition, while a complete absence of fluid causes a more speedy return to a normal condition.

Instead of irrigation of the canal, some surgeons prefer after incision of the drum membrane, to insert a strip of sterile gauze into the meatus, thus securing drainage, a sterile dressing being applied over the ear. If this plan is followed, it is necessary to change the dressing at least twice daily. This, in private practice, naturally entails considerable loss of time on the part of the surgeon. Moreover, the continued presence of the discharge in the canal tends to cause a softening of the tissues of the meatus, and not infrequently local infection of these tissues occurs. In my own experience, this method of drainage has proved very inferior to the treatment of these cases by regular irrigation.

In cases of spontaneous rupture the opening may be so small that drainage is not perfect. When these cases are seen late in the course of the disease, our first efforts should be directed toward enlarging the opening and thoroughly cleansing the tympanic cavity by driving out the contained fluid with the air douche. If this does not suffice, the tympanum may be washed out with a saturated solution of boric acid by means of the middle-ear syringe (shown in Fig. 99). If examination shows the lining mucous membrane to be considerably thickened, the instillation of a few drops of a two-per-cent solution of nitrate of silver or a four-per-cent solution of sulphate of zinc suffices to correct the condition. In many cases a single application is followed by a complete cure. The medicinal solutions are instilled either with the middle-ear syringe or a simple middle-ear pipette of glass. Care should be taken when nitrate of silver is used to begin with a very weak solution, since the patient may possess a peculiar idiosyncrasy toward this drug, and the reaction following its application may be severe. If, after the first trial, we find the parts tolerant, the strength may be gradually increased until the desired results are obtained. When the pharynx is filled with hypertrophied lymphatic tissue, we find that the case is particularly liable to a relapse when the discharge has almost ceased. There is no reason why the presence of an otitis media of this character should influence us to delay the removal of the hypertrophied lymphatic tissue after the acute aural symptoms have subsided. Its removal will be necessary to prevent subsequent similar seizures, and will certainly favor a rapid termination of the present attack.

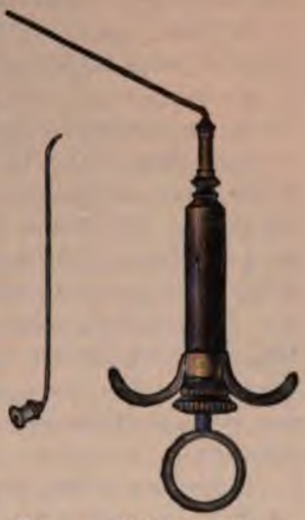


FIG. 99.—Blake's middle-ear syringe.

After the opening of the membrana tympani is closed, the patient should be kept under observation until the parts present a perfectly normal appearance. A certain amount of relaxation of the drum membrane and of the intratympanic ligaments follows an inflammation of this character, and may result in the formation of adhesions in the tympanum unless certain measures are instituted to prevent it. Inflation of the middle ear should be practiced at first daily, and subsequently at longer intervals, until all traces of congestion disappear and the membrane retains its normal position.

In these cases, and also in instances where the membrana tympani remains intact, a certain amount of fluid may be left in the middle ear. The application of stimulating vapors to the lining membrane of the cavity will hasten absorption of this residual fluid. For this purpose nothing is better than the vapor from an alcoholic solution of menthol, sixty grains to the ounce. Oil of eucalyptus, or pine-needle oil of the strength of a drachm to the ounce, may also be employed, the vapor being conveyed to the middle ear through the Eustachian catheter. The introduction of simple or medicated steam into the tympanum has fallen somewhat into disuse. It possesses no advantages over dry vapors, and its use is attended with a certain amount of discomfort to the patient and is tedious for the operator.

Subjective noises may persist for a considerable time after hearing has returned to a practically normal condition. The question of a secondary inflammation of the labyrinth presents itself at this period. From observation of a large number of patients we find that the labyrinth is seldom seriously involved in this disease. The subjective noises ultimately disappear when the mucous membrane of the tympanum returns to an absolutely normal condition. The failure of this symptom to disappear need give rise to no uneasiness. When the noises are particularly distressing, relief is obtained by the administration of dilute hydrobromic acid in doses of thirty to forty-five minims two or three times daily. The susceptibility of the receptive centres is blunted, and after the noises have once disappeared they seldom recur. It is wise to avail ourselves of the use of the drug, since the continued stimulation of this part of the receptive apparatus rather militates against an early disappearance of the symptom.

CHAPTER XX.

ACUTE PURULENT OTITIS MEDIA.

THE presence of pus in any locality depends upon a necrotic process involving the deeper tissues of the region. In the middle ear the upper portion of the tympanic cavity presents an exceedingly favorable site for the development of a purulent inflammation, since in this region considerable connective tissue is present, forming the framework of the mucous reduplications of the tympanic vault, as well as of the ligamentous bands fixing the ossicles to the walls of the tympanum and uniting them to each other.

A purulent otitis media primary in character is indicative of an infection in this region, as distinguished from a similar process involving the lower portion of the tympanic cavity.

Ætiology.—In order that tissue necrosis may take place, the organism producing it must possess a certain amount of virulence. One of the most common causes, therefore, of purulent otitis media is some acute infectious disease. The affection most frequently followed by the disease under consideration is measles, although it may appear during the course of scarlatina, pneumonia, epidemic influenza, variola, typhus, or cerebrospinal meningitis. It oftens follows the introduction of fluid into the middle ear through the Eustachian tube. The extension of an external otitis, either diffuse or circumscribed, may set up a purulent otitis media, access to the middle ear being gained through the Rivinian segment. The rupture of the drum membrane, either from any foreign body introduced into the meatus or by violent inflation of the tympanum, may be followed by a similar result.

Occasionally vegetable molds developing in the canal involve the middle ear by continuity. A purulent inflammation in any other part of the body may infect the tympanic cavity secondarily, although this is an uncommon occurrence. As stated in the previous chapter, the disease may follow an acute catarrhal otitis media by infection of the exudation either through the Eustachian tube or after it has gained an exit through the drum membrane and appeared in the external meatus.

Pathology.—The first stages of the process consist in a hyperæmia of the affected parts. The folds in the vault of the tympanum become engorged with blood, increase in volume, and often fill the space completely, shutting off all communication with the atrium. This period of congestion is followed by a transudation of the fluid elements of the blood and a migration of white blood cells. Following this, local necrosis takes place, the tissue breaking down with the formation of pus. A bacteriological investigation of the discharge in these cases will most frequently reveal a streptococcus infection. Occasionally a pneumococcus will be found. In order that the connective-tissue structures of the vault may be invaded, it is necessary that the germ causing the infection should be one of considerable virulence, the less active varieties of infectious germs not being sufficiently virulent to attack connective-tissue structures. As the result of the local œdema the blood supply of the ossicular chain is considerably interfered with, and bony necrosis may occur quite early. This usually takes place first in the incus, on account of the limited blood supply in proportion to its size, and the fact that its nutrient vessels pursue such a course as to be subjected to pressure quite early in the attack. The surrounding walls of the tympanum may also become involved, although this rarely occurs early in the disease. Occasionally the process may start as an acute osteitis either of some portion of the ossicular chain or of the bony walls of the tympanum, the soft parts being involved secondarily. This condition is occasionally met with in patients suffering from tuberculosis.

After the inflammation is fully developed and the parts have become engorged with blood, transudation of the fluid elements of the blood takes place, together with migration of the white blood-corpuscles which pass out of the vessels into the surrounding tissue; the fluid transuded naturally gravitates to the lowest portion of the cavity. The exact position occupied by the fluid will depend upon the particular formation of the tympanum in any individual case; occasionally the mucous folds are so developed that the transudation is confined and does not enter the general tympanic cavity. It will be remembered that the long process of the incus passes downward from the body of the ossicle into the atrium; this fact plays an important part in the cases under consideration, since, when the tissues within the tympanic vault are much swollen, the long process of the incus forms a natural drain along which the fluids may pass into the lower portion of the tympanic cavity from the space above. We find that where the inflammatory products from the vault collect in the atrium and subsequently perforate the membrana tympani this perforation lies in the upper and posterior quadrant close to the tympanic ring and just below the incudo-stapedial articulation. The fact that perforations located in this region are persistent and that the inflammaory processes developed here are specially painful is a fact that has long been noted; its particular significance, however, has been explained but lately. Sometimes, owing to the topography of the organ, the upper part of the cavity is completely divided from the lower portion. The inflammatory products in these cases can not pass along the descending arm of the incus into the atrium, and therefore crowd the upper portion of the membrana tympani outward. This bulging of the membrana flaccida is particularly characteristic, and is sometimes present to such a degree that the distended portion sinks down over the membrana vibrans, partially or completely concealing it from view. I have seen one instance in which the bulging was so extensive that the membrana flaccida protruded from the meatus and might easily have been mistaken for a polyp. Upon incision a large amount of fluid was evacuated, retraction took place, and examination revealed the opening in the superior quadrant just above the posterior fold. It is probable that those cases of otitis media in which the atrium seems to be the primary seat of purulent inflammation are really instances in which the inflammatory products have passed from the vault into the atrium along the long process of the incus, as it is hardly possible for a purulent inflammation to originate in a cavity whose mucous lining is closely applied to the bony walls. Where evacuation does not occur, either spontaneously or at the hand of the surgeon, the fluid may dissect the soft tissues of the canal for a certain distance along the superior and posterior wall, since in this region the periosteum of the canal is directly continuous with the membrana flaccida and is but loosely attached to the bony margin of the meatus. This gives rise to a sinking of the postero-superior wall of the meatus and a narrowing of the deeper portion of the canal. The pus may burrow along the entire length of the wall and make its appearance in the post-auricular region as a soft, fluctuating swelling. This is particularly liable to occur in children, where the tissues are less firmly attached to the parts beneath, and the membrana tympani is so superficially placed. Cases of this class are particularly prone to mastoid complication.

Examination of a large number of cases teaches us that the mastoid is usually involved before the soft parts covering the postero-superior wall of the canal become detached from the underlying bone. Hence, evidence of a collection of fluid in this region constitutes an almost pathognomonic sign of mastoid inflammation. In children, where the purulent collection has dissected off the posterior wall of the canal and formed a post-aural abscess, the periosteum on the outer surface of the temporal bone may become detached unless the fluid is freely evacuated, and infection of the intracranial structures may take place either through the mastoid squamous fissure which remains open for a considerable period after birth, or a localized caries or necrosis of the squamous portion may take place on account of interference of the blood supply, and direct infection follow. Several cases of this character have been reported, and it has fallen to my lot to witness two *—one in a child and one in an adult. The involvement of the cranial contents in this manner is the exception, the infection usually taking place either through the tympanic roof or through one of the large venous sinuses in the immediate neighborhood of the middle ear. Either condition may occur by a transmission of the infecting material through the communicating venous channels, or local caries may take place and a large amount of pus be brought in contact with the surface of the meninges or enter directly into the blood current through one of the large sinuses.

Symptomatology. — The characteristic symptoms of an acute purulent otitis is sudden and excruciating pain deep within the ear. Attending this we have a decided elevation of temperature, the thermometer registering from 101° to 103°, severe headache, constipation, and marked constitutional depression. The hearing becomes rapidly impaired, there is often distressing tinnitus, and in some cases vertigo. When the disease occurs in children the symptoms are even more marked, the attack being frequently ushered in with general convulsions. The pain changes quickly from one localized within the ear to a rather diffuse headache upon the affected side. In severe cases even in adults delirium is occasionally present. High temperature in marked contrast to the very moderate increase observed in an acute catarrhal inflammation indicates the more profound constitutional infection. The pain continues unabated unless relieved artificially until the inflammatory products are evacuated. This may not occur for several days if the condition is not interfered with. The occurrence of discharge offers some relief to the pain, although it does not entirely remove it, since the tissues are so œdematous that the opening is seldom large enough to permit free drainage. The fluid that fills the auditory canal is usually at first seropurulent, but quickly changes to a distinctly purulent character. Involvement of the mastoid cells may occur before the appearance of discharge or at a subsequent period. In either event it is characterized by increased pain, and an augmentation in the severity of all of the general symptoms. The location of pain changes somewhat and is referred to the region immediately behind the auricle rather than to the ear itself. Involvement of the structures within the cranial cavity is usually characterized by an increase in the temperature, violent delirium, convulsive movements followed by paralysis or paresis, either upon the corresponding or the opposite side, according to the particular area involved. When invasion of one of the large sinuses of the dura mater takes place either from the middle ear itself or from the subsequent mastoid involvement, symptoms of pyæmic infection appear. These are a sudden high temperature, frequently reaching 105° or 106°, with an equally sudden return to normal or even to subnormal, profuse sweating, and rigors. These changes in temperature are repeated at intervals varying from a few hours to one or two days.

---

* Archives of Otology, vol. xxi, p. 253.

Evidences of extension to the labyrinth are the sudden appearance of dizziness, nausea, and either absolute deafness for all notes or complete loss of perception for certain portions of the musical register, usually the high notes of the scale. Extension in this direction is rather unusual, a fact which would suggest that the vascular communication between the middle ear and the labyrinth through the intervening bony wall is not as extensive as the investigations of Politzer * would cause us to believe.

Diagnosis.—A. *Physical Examination.*—Recognition of this condition in its very early stages is of the utmost importance, since the disease is always a severe one, being dangerous not only to the function of the organ, but often to life itself. Particular attention should be given to an inspection of those parts lying above the short process of the malleus whenever severe pain in the ear is complained of. It is the rule that in the very early stage that portion of the membrana tympani alone, lying above the short process of the malleus, is the only part which presents the slightest departure from the normal appearance. Here close inspection will reveal the fact that the membrane is distinctly congested, presenting a deep dull-red color characteristic of a high degree of venous engorgement of the underlying structures. This hyperæmia does not extend below, and frequently not as far as the posterior fold, and, if a hasty examination be made, may entirely escape observation. It is in this very early stage that prompt measures may serve to abort the attack; hence the stress which is laid upon the physical characteristics.

When viewed somewhat later, well-marked engorgement of these structures is seen to be present, the membrana flaccida being pushed outward and somewhat downward (Fig. 100). The entire region is of a deep-red color, the parts being œdematous, the external surface moist, and the normal lustre entirely wanting. The tumefaction may be so great as to actually sink downward into the canal to the level of the short process, or may overhang it. When well advanced, the hyperæmia becomes general, and involves the entire tympanic membrane. Sometimes the short process may be completely hidden by the œdema of the surrounding parts, although this landmark can usually be found if sought for carefully. The outline of the manubrium is almost always lost.

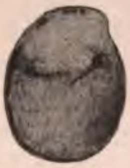


FIG. 100.—Acute purulent otitis media; bulging of membrana flaccida.

In cases complicating scarlatina, or any disease where the infection has been sudden and violent, an appearance which may deceive is one in which the membrana tympani presents a dead-white color. This is due to a necrosis of the superficial epithelium covering it, the loss of lustre being characteristic of the condition. This superficial layer is easily removed by the cotton-tipped probe, and reveals the red membrane beneath. Where fluid has drained into the lower portion of the tympanic cavity the entire membrana tympani may bulge into the canal instead of presenting a localized bulging area at the upper part. The appearance then does not differ from that shown in Fig. 98. The secretion may be so confined by the mucous folds within the tympanum as to present, upon examination, several tumefied masses lying in the fundus of the canal close to the superior wall. These may be two or three in number, according as the fluid is confined in the anterior and posterior pockets of the membrane, or has entered these and the median space known as the pocket of Troeltsch as well (Fig. 101). Inspection of such a case, where a clear history can not be obtained as to the length of time the disease has lasted, is misleading, the bulging areas being frequently mistaken for masses of granulation tissue. Where perforation has taken place spontaneously, we most frequently find the opening in the posterior portion of the membrane, just above the centre and near its peripheral attachment. It may also appear above the posterior fold and be entirely within the membrana flaccida. When this occurs it usually forms the apex of an irregular conical projection from Shrapnell's membrane, the margins of the perforation being swollen and irregular in outline.

---

* Arch. für Ohrenheilk., vol. xi, p. 237.

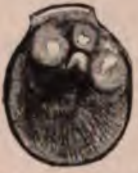


FIG. 101.—Acute purulent otitis media; fluid confined in the pockets of the membrane.

Forcing air into the middle ear through the Eustachian tube before perforation has taken place may not reveal the presence of fluid, since the collection may be confined entirely to the vault. After perforation has taken place, even vigorous efforts at inflation may not force air through the opening in the drum membrane, and give rise to the characteristic perforation whistle. It may even fail to force any secretion from the tympanic cavity on account of the extreme swelling of the lining membrane.

B. *Functional Examination.*—The functional examination in these cases reveals a condition identical with that described in the preceding chapter on acute catarrhal otitis media.

When the labyrinth is encroached upon by extension through the oval or round window, we find, in addition, the diminution in bone conduction and loss of perception of upper notes of the scale.

Prognosis.—An otitis media of this variety can terminate in spontaneous recovery without loss of tissue only when the inflammatory process does not progress beyond the stage of congestion. When once pus is formed it must be evacuated, and hence resolution is impossible after this period. With the evacuation of the fluid the perforation may heal and the parts be restored to their normal condition. Such a fortunate termination is seldom to be looked for, however, under the most favorable conditions, and cases which are untreated usually present, after the disease has run its course, a destruction of the membrana tympani over a greater or less area.

The internal wall of the middle ear may be covered by a cicatrix extending from the margins of the opening in the tympanic membrane to the osseous wall of the middle ear, practically converting it into a closed cavity. In other instances where the membrana tympani has been almost completely destroyed we find the internal wall presenting a pale, glazed appearance; the parts are perfectly dry, and the mucous membrane has become changed to one which does not secrete moisture. Again, the internal wall of the tympanum may be somewhat thickened and moistened by its normal mucous secretion without any discharge appearing in the canal. The ossicular chain is usually bound down to the internal tympanic wall at various points by cicatricial bands. The amount of interference with the function varies in different cases and depends upon the location of adhesions.

In the majority of instances, in cases which have been untreated during an acute attack, a chronic purulent otitis develops, and careful investigation will show areas of bony necrosis either in the walls of the tympanum or confined to the ossicular chain. The location of the perforation and its diagnostic significance in cases where the discharge persists will be more fully dwelt upon in the consideration of chronic purulent otitis media.

Death may result from the disease, from direct involvement of the cranial contents, either directly or after the development of mastoid inflammation. This last complication is of common occurrence where the disease does not come under observation in the acute stage. The prognosis as to the integrity of function is rather better than might be expected when we consider the extensive loss of substance which the malady entails. Serious labyrinthine involvement is decidedly the exception, and when the labyrinth is involved the invasion is usually primary, dependent upon the same cause that has produced middle-ear inflammation, rather than secondary to the tympanic disease.

Treatment.—Vigorous measures must be instituted in the earliest stages if we hope to abort the affection. When in the course of an acute infectious disease severe pain is complained of in the ear, and inspection reveals the characteristic congestion already mentioned, immediate local depletion should be instituted. As much blood as the general condition of the patient will permit should be abstracted from the region in front of the tragus. The administration of an opiate to relieve pain is not advisable in these cases, since whatever measures are to be instituted for the relief of the local condition must be employed in the course of a few hours, and it is unwise to mask any advance of the disease by blunting the susceptibility of the patient to the intensity of the pain. If local depletion does not produce immediate relief, the parts should be thoroughly incised. This operation is intensely painful, but quickly performed, and the wisdom of administering a general anæsthetic must depend upon the condition of the patient. During the last few years I have operated on most of these cases under nitrous oxide anæsthesia, and have found it satisfactory in every instance. The incision should lie above the short process of the malleus and posterior to it (Fig. 126). The knife is entered behind the processus brevis and carried upward and inward parallel to the neck of the malleus until it has pierced the cellular tissue in the tympanic vault and impinges upon the bony wall. The knife is then swept backward to the periphery of the membrane, the deep tissues being divided throughout the entire extent of the incision. If the long process of the incus is encountered, as may happen if it lies high up in the cavity, or if the incision is carried a little too low, care must be taken not to displace it, the knife being allowed to glide over it, and afterward being pushed inward to the original depth to complete the incision. It is well, also, on reaching the periphery, to extend the section directly outward along the supero-posterior wall for a distance of a quarter of an inch, dividing all the soft parts down to the bone. Very free bleeding follows this operation, and the hæmorrhage should be encouraged by irrigation of the canal with warm boiled water. It is to be distinctly understood that we do not expect to liberate pus by this procedure, but to prevent its formation. Consequently the greatest care must be taken that the field of operation is in an aseptic condition, and that all instruments and the fluid used subsequently in irrigating the region are thoroughly aseptic. This measure, when performed sufficiently early, may completely abort the attack; the divided tissues unite firmly at the end of a few days, and all symptoms referable to the ear may disappear completely. When seen at a later period, and when the parts are distinctly bulging, it is wise to vary the procedure to the extent of beginning the incision over the area of the greatest bulging, remembering that our object is to incise the vascular tissues located in the superior portion of the cavity, and to liberate any contained fluid as well. Here, instead of carrying the incision outward upon the canal wall, the knife may be plunged directly into the most prominent portion of the tumor, carried deeply into the tympanic vault, and the parts divided directly upward as far as the superior margin of the meatus (Figs. 87 and 97); the peripheral attachment of the membrane posteriorly should then be followed downward for a short distance, thus forming a triangular flap, to favor free drainage. When spontaneous perforation has taken place we usually find it necessary to enlarge the opening. This measure should be carried out according to the rule which governs the primary incision.

Upon the appearance of discharge after spontaneous rupture, or after surgical interference, the canal must be kept as free as possible by frequent irrigation with a warm antiseptic solution. This both relieves pain and is of great importance in preventing a localized infection of the canal. This is preferable to draining with a strip of gauze, as already described on page 338. The development of a furuncle during the course of the disease is to be especially avoided, as it may mask an involvement of the mastoid process, or may be mistaken for this condition. A localized tumefaction of the canal indicative of mastoid involvement is situated at the fundus, upon the postero-superior wall of the meatus, and close to the drum membrane (Fig. 78). In this region the development of a primary infectious process in the canal wall is exceedingly rare, circumscribed otitis externa usually occurring in the fibro-cartilaginous portion. Tenderness upon deep pressure over the mastoid, care being taken not to communicate any motion to the movable part of the canal during the examination, will also aid us in deciding that the mastoid is involved, while tenderness on pressure about the ear, which imparts a certain amount of motion to the fibro-cartilaginous portion of the meatus, or on traction upon the auricle, will point to a circumscribed external otitis of a simple character.

When the symptoms point to mastoid involvement, great caution is necessary in order that measures may be undertaken at a sufficiently early period to prevent this complication. With the accession of any tenderness over the mastoid region, either directly over the antrum or at the apex, the Leiter coil or aural ice bag may be applied and kept in position continuously for a period of not over thirty-six hours. In addition to this, attention should be given to the primæ viæ. The diet should be light, and any tendency to constipation should be overcome by the free use of saline cathartics. Any tumefaction of the tissues at the upper and posterior part of the bony meatus close to the drum membrane should be immediately incised, since the relief of tension here, in conjunction with cold externally and frequent irrigation of the canal, will usually abort the attack. Here, again, it is not advisable to administer drugs for the purpose of relieving pain, or certainly not for any long period. If the pain in the mastoid region remains moderate for twenty-four hours, and manipulation elicits an increase in the amount of tenderness, it may be wise to insure a fair amount of sleep for one night by the administration of morphine. This plan should not be repeated, for if on the following day no marked amelioration of the symptoms is present, operative measures directed to the mastoid process should be at once instituted. I was formerly much more in favor of the use of the ice-coil as an abortive measure in the treatment of mastoiditis than I am at present. A more extensive experience has taught me that the cases of mastoid congestion which will be prevented from going on to suppuration and to extensive destruction of the bony tissues by means of the ice-coil are exceedingly rare. At present I am in favor of using abortive measures of any kind only in the very earliest stages of the disease. If a case is seen within twenty-four or forty-eight hours from the beginning of the acute otitis, and if at this time some mastoid tenderness is present, the surgeon is then justified, after establishing free drainage through the meatus, in applying the ice-coil to the mastoid for a period of thirty-six, and possibly for a period of forty-eight hours, but certainly for no longer time. At the end of this time the ice-coil should be removed and should not be reapplied. Any beneficial effects which will result from the local application of cold will have been obtained at the end of thirty-six to forty-eight hours. If tenderness persists after the use of cold for this length of time, no further abortive measures should be attempted, but the surgeon should enter the mastoid at once. In doubtful cases the otologist is perfectly justified in exposing the mastoid antrum for exploratory purposes. Under proper aseptic precautions, no harm can result from this operation, and early interference may save the patient a prolonged convalescence following a more severe operative procedure. I can hardly speak favorably of local bloodletting over the mastoid region. Occasionally it may be followed by relief; but my experience has been that, where blood has been abstracted from this region, the symptoms have been delayed only, but the complication has not been prevented. Another objection to local bloodletting lies in the fact that the tenderness of the parts to which the measure gives rise may mask that due to the inflammation of the osseous structures. This is not a serious objection, to be sure, and a little care on the part of the surgeon will enable him to distinguish between superficial and deep tenderness. At the same time it is important for us to recognize the fact of mastoid involvement as soon as it takes place, and not delay prompt interference. Any measures which temporarily relieve the symptoms, or cause the disease to progress more slowly, are of a decided disadvantage, and often a menace to life. The particular operative measures to be adopted when the mastoid is involved will be fully described in the section devoted to surgery. It should be stated here, however, that the author is decidedly averse to the employment of a simple incision over the mastoid in these cases. The value of the so-called "Wilde's incision" depends upon the depletion and a certain amount of relief to tension secured by division of the periosteum. The operation is exceedingly painful, and a general anæsthetic is usually necessary. In all cases where the Wilde incision is positively demanded it will probably be necessary to enter the mastoid at a later period; and to give the patient an anæsthetic upon one day for the purpose of making a superficial incision, and to repeat it a day later for the purpose of completing the operation and entering the mastoid process itself, is absolutely unjustifiable. When, therefore, external incision seems indicated, but the surgeon does not feel justified in entering the bone, it is much better to wait for twenty-four or forty-eight hours, at which time no doubt will exist as to the proper course to pursue. Incision within the canal has already been spoken of, and is in reality an internal Wilde's incision. The pneumatic cells of the mastoid are located much nearer the superior wall of the meatus than to the external surface of the mastoid cortex. This incision in the canal frequently relieves tension sufficiently to prevent an extension of the inflammation. Whenever internal incision will not relieve the condition within the mastoid, external incision certainly will not, and in adults it should be a cardinal rule never to depend upon the operative measure of dividing the soft parts alone. In children under three years of age, where the mastoid cortex is thin and the cells may be opened with a stout scalpel, the procedure may occasionally be justifiable; but even here experience has taught me that a complete operation under general anæsthesia is better than to incise the superficial structures simply and secure imperfect drainage. The opening must be small, and no knowledge of the extent of the tissue involved can be gained, while the exit to the discharge can not be free. Therefore, whenever any operative procedure is instituted upon the mastoid it should be thorough, and should be performed under general anæsthesia.

We occasionally meet with cases which, after incision of the membrana tympani and the establishment of drainage, progress favorably for a certain period, after which—probably because of a fresh access of inflammation—the discharge increases in amount, the pain returns, and the symptoms are repeated, although not to the same degree. Here it may be necessary to re-incise the drum membrane and thoroughly evacuate the contents of the tympanic cavity. Each recurrence incurs the danger of mastoid inflammation, and to delay the establishment of free drainage through the external meatus, in the hope that the inflammatory process may disappear spontaneously, is certainly unwise. If the parts are kept thoroughly cleansed and attention is paid to the proper exit of the discharge, very little local treatment is necessary aside from this. Occasionally, owing to the impoverished general condition of the patient, or to some obstructive lesion in the upper air passage, especially to enlargement of the pharyngeal tonsil in children, the discharge becomes small in amount and assumes a watery character, but does not cease completely. Here attention to the general health is of prime importance, since if the discharge is allowed to continue too long the ossicles are apt to become involved, and a chronic purulent otitis may be established. If the pharyngeal vault is the seat of adenoid vegetations, these should be removed.

While it may occasionally be justifiable to incise the membrana tympani a second time, in the hope of preventing the extension of an inflammatory process to the mastoid, I am inclined to believe that where a myringotomy has been done once, and been done thoroughly, and where the incision has been carried out on to the upper wall of the canal, in the manner already described, the surgeon will be wasting time in attempting to relieve the patient by a second incision of the drum membrane. Of course, it is possible, as stated above, that reinfection may occur at a comparatively late date and after the opening in the membrana tympani has almost entirely healed; these cases, however, are extremely rare. Where the drum membrane has been once thoroughly incised and at a later date symptoms of incomplete drainage make their appearance, it is better to open the mastoid at once and to secure free drainage posteriorly, than to temporize by resorting to a second myringotomy. Such a procedure will probably fail to relieve the patient, and the necessity of operative treatment on the mastoid will be simply postponed and not prevented. We know from experience that the longer such operative treatment is delayed, the more extensive is the destruction of the bony tissues. It is wise, therefore, for the surgeon to open the mastoid upon the first evidence that drainage through the meatus is incomplete.

In case the discharge does not cease as promptly as might be expected, owing to inattention on the part of the patient regarding thorough cleansing of the canal, granulation tissue may develop along the margins of the incision or spontaneous perforation in the membrana tympani, or the mucous membrane within the tympanic cavity may become greatly hypertrophied and protrude through the perforation in the form of a pedunculated mass, constituting an aural polyp, so called. This obstructs the free outflow of the secretion, and must be either removed or destroyed *in situ*. Removal may be easily effected by means of a delicate snare armed with fine wire. For destroying these exuberant granulations either chromic acid or the fused bead of nitrate of silver may be used. Care should be taken to thoroughly dry the granulations before the escharotic is applied and to make the application to the hypertrophied tissue only, and not allow it to spread to the surrounding parts. This is effected by lightly touching the parts which have been cauterized with a pledget of dry cotton immediately after cauterization, to remove any excess of the agent employed. If delicately executed, the procedure is not painful, but it is always wise to anæsthetize the part with a ten-per-cent solution of cocaine, previous to cauterization. Chromic acid, I think, is the safer agent to employ, as nitrate of silver is sometimes followed by a rather sharp reaction.

Again, the hypertrophied covering of the internal tympanic wall, instead of assuming a distinctly polypoid appearance, may present as a diffuse thickened membrane. This occurs especially when the perforation is of large size, exposing the tympanum over a considerable area. Here we make use of the metallic astringent salts in aqueous solution, nitrate of silver being the favorite, although sulphate of copper, sulphate of zinc, chloride of zinc, or the persulphate of iron may be employed probably with equally good results. The strength of the solution used must vary with the special condition of the parts. It is always well to test the susceptibility of the patient by beginning with weak solutions and to increase the strength according to indications. The silver solutions may be used in strengths of from two to fifty per cent; the zinc salts in strengths of from two to four per cent. If sulphate of copper is employed the degree of concentration should not exceed ten or fifteen grains to the ounce.

The persulphate of iron seems to be of particular value in causing a rapid disappearance of granulations developed about the margins of a perforation. The solution may be used full strength or diluted with water, according to the size and character of the granulations. The patient should be seen the day following such applications, as occasionally the reaction will cause closure of the opening in the drum membrane, and symptoms dependent upon pus retention may supervene.

When only a small quantity of discharge remains we may find that the use of fluid in the canal increases rather than diminishes the amount of discharge. If the case is watched closely, astringent or antiseptic powders may be employed, care being taken that the opening in the membrana tympani is not occluded, the powder being insufflated so as to form a thin covering over the membrana and the canal walls. If this plan is adopted the patient must be seen daily by the surgeon and the parts thoroughly cleansed by means of the cotton pledget, after which the powder is lightly dusted over the membrana tympani, the granulations, or the exposed wall of the middle ear, as the case may be. We may use boric acid, iodoform, iodol, or dermatol. When the walls of the canal appear sodden from long-continued irrigation, the addition of a small amount of oxide of zinc to any of the above powders is desirable. This protects the denuded lining of the meatus and favors the formation of normal epithelium. After the opening in the drum membrane is closed, inflation should be employed at first daily, the interval being increased as the parts resume their normal appearance. It is important that this plan should be carried out; otherwise adhesions may develop in the tympanum and the function of the organ be decidedly impaired.

CHAPTER XXI.

CHRONIC CATARRHAL OTITIS MEDIA.

UNDER chronic catarrh of the middle ear various affections of the tympanum have been described. The selection of this name is particularly unfortunate, since it conveys the impression that the disease is really a complicating lesion of some condition in the nose or naso-pharynx. "Catarrhal deafness" is a term which appears not only in our standard works upon otology, but also forms a prominent feature of the advertisement of almost every charlatan.

In the first place, catarrh as a disease does not exist, it being merely a term used to describe a symptom, meaning from its derivation simply a discharge. By common consent catarrhal inflammation is the term applied to a simple inflammation of any mucous membrane. It may occur in the ear or elsewhere, constituting a primary disease entirely independent of any lesion in the upper air passages.

When the mucous membrane of the middle ear is the seat of such a chronic inflammatory process the changes which take place are of two varieties: In one form, which may be termed a hypertrophic inflammation, we have a swelling of the lining membrane of the tympanum, due usually at first to a chronic venous congestion; this continuing for a long period results in hypertrophy of the elements of the tissue lining the cavity. Over the bony internal wall of the middle ear the mucous membrane is thickened and hyperæmic and the glandular elements produce, therefore, an excessive amount of secretion. In the drum membrane the same process takes place; the fibrous layer becomes thickened in places, and may over certain areas be the seat of calcareous deposits. The same changes take place in the ossicles, ligaments, and in the walls of the Eustachian tube. Owing to the chronic hyperæmia, serum or sero-mucus may collect in the cavity and remain there permanently, or the fluid may disappear from time to time when the congestion is less marked.

In contradistinction to these changes, we find in another class of cases a process characterized by tissue hyperplasia rather than by hypertrophy; the new tissue is firm and fibrous in character, secretion is diminished, the walls of the vessels supplying the parts are thickened, and a true sclerosis results. In this form of inflammation the favorite site of the inflammatory process is the region of the oval and round windows. The outer wall of the tympanum—that is, the membrana tympani—may present almost no variation from the normal appearance. In the Eustachian tube the tissue changes cause an actual increase in the calibre of the canal as the membrane becomes firmer and more closely applied to the parts beneath. In the tympanic ligaments this sclerotic process increases their firmness, binding the ossicles rigidly together and fixing them firmly within the cavity, so that the degree of motion in every direction is much reduced. About the stapedial niche we find dense connective-tissue bands running from the head of the stapes and from the crura to the walls of the pelvis ovalis. The motion of this ossicle is therefore greatly limited. At the round window similar changes prevent the compensatory movements of the membrana tympani secondaria and render the vibratory motion of the labyrinthine fluid difficult or impossible. Whether the hyperplastic form of inflammation is often secondary to the hypertrophic form is a mooted question, but the weight of evidence seems to favor this view.

CHRONIC HYPERTROPHIC OTITIS MEDIA.

Ætiology.—A chronic hypertrophic inflammation within the tympanum may follow an acute catarrhal otitis, an acute congestion of the Eustachian tube which has failed to resolve completely, or a similar process in which the middle ear and tube are both involved. It may also occur as an idiopathic affection, the organ never having been the seat of an acute inflammation. In any case where the disease is chronic from the beginning it depends upon some fault in the manner of life of the patient through which he becomes particularly susceptible to vascular changes in those portions of the body lined with mucous membrane. Frequent exposure to cold resulting in repeated attacks of acute rhinitis or acute naso-pharyngitis, from which the vessels within the tympanum are frequently engorged with blood, is a most common cause. The condition may begin in early life from the presence of a moderate amount of adenoid tissue in the pharyngeal vault, not enough to give rise to symptoms of nasal obstruction, but sufficient to cause a venous engorgement of the parts with each exposure to cold. This condition interferes with the intratympanic circulation, and, although the pharyngeal tissue may become entirely normal in later life, the changes set up within the middle ear may persist and even increase although the cause of the affection has disappeared. The disease is more commonly met with in individuals whose occupation renders exposure to inclement weather a matter of necessity; it is hence more common in males than in females. No period of life is exempt from the disease, but it occurs more frequently between the ages of fifteen and thirty-five than before or after this period. Marked impairment of the general health, either from a severe illness, from prolonged mental anxiety, or from privation, constitutes a factor in the causation of many cases. The abuse of alcohol also exerts a certain effect in the production of the disease, both from its local action upon the digestive organs and its influence upon the circulatory system. We are often told that the aural lesion is due to the extension of inflammation from the pharyngeal vault because of the continuity of anatomical structure. While this may be so, it is certainly a question of little importance, since the same causes acting to produce the pharyngeal inflammation may exert their effect primarily upon the lining membrane of the tympanum. The excessive use of tobacco is not responsible for the disease under consideration, except as it may affect the general health; the inhalation of smoke produces quite as deleterious an effect upon the respiratory organs and middle ear from local action as does the actual use of the weed.

The opinion so prevalent, that impaired hearing due to catarrhal inflammation of the tympanum is to a certain extent hereditary, is not entirely borne out by experience. A careful examination of statistics shows that in the disease under consideration heredity plays a very unimportant part in the causation. It is true that certain families seem to show a particular predisposition to inflammations of the lymphatic type, engorgement of the lymph nodules occurring with any slight local inflammation. This is seen if we observe the frequency with which adenoid vegetations are observed in different members of the same family through several generations. Since these growths exert an influence upon tympanic conditions, it is not strange that the belief should be held that the aural affection is transmitted from one generation to another. In many cases, however, we find the pharyngeal lymphatics enlarged through several generations without any aural affection. It is probable, therefore, that the influence of heredity is limited to the lymphatic deposits, which render the ears more easily affected by slight changes. It is seldom that any hereditary history of the aural disease is met with without the accompanying lymphatic taint.

Pathology.—The pathological changes have been described somewhat at length in the introductory remarks. To recapitulate, they consist in a swelling of the lining membrane of the tympanum, due at first to a venous congestion, but afterward to an actual tissue hypertrophy. The newly formed tissue is vascular and richly supplied with cellular elements, the fibrous elements being but little developed. An actual increase in volume is the result of this process, and is characteristic of this form of inflammation. The presence within the tympanum of a fluid exudation, due either to an abnormal activity of the secretory glands or to the transudation of the fluid elements of the blood from the engorged vessels, constitute another prominent feature. No particular portion of the middle ear is involved by preference, even the membrana tympani sharing in the changes wrought by the morbid process. In the membrana tympani there is thickening of the mucosa and swelling of the fibrous layer, followed by true hypertrophy here, and in the advanced stages by a deposit of the lime salts.

As involving the drum membrane, the structural changes produced are usually more marked in some parts of the membrana tympani than in others. This results in an irregularity of texture, some portions appearing dense and opaque, while others, by contrast, appear thinner than normal (see colored plates). In the Eustachian tube the tissue changes within the walls narrow its lumen, and prevent the entrance of air into the middle ear. This reduces the tension within the middle ear, and causes depression of the membrana tympani from atmospheric pressure. A gradual stretching of the drum membrane takes place from the continued pressure from without, until finally further displacement is prevented by contact with the internal tympanic wall. The pressure against this resisting barrier increases the local inflammatory process.

The movement of the drum membrane inward and its persistence in this position is favored by the action of the tensor tympanic muscle, which by contraction draws the membrane inward against the wall of the middle ear. From disuse the tendon becomes shortened, this change being aided by the inflammatory process. If now the Eustachian tube is restored to its normal patency, the membrana tympani does not assume its correct position, and it may even be impossible to replace it by artificial means. Similar changes occur in the intratympanic ligaments if the parts are suffered to remain misplaced for a considerable length of time. Of the ligaments which bind the ossicular chain together the capsular ligament of the malleo-incudal articulation suffers the most. It may become relaxed, and render displacement of the ossicular chain more easy. From the relaxation of this ligament the entire drum membrane and the tip of the handle of the malleus may be carried directly inward toward the tympanic wall by rotation of the malleus upon the axis band. The separation of the articular surfaces of the malleus and incus prevents the perfect transmission of the aërial vibrations to the stapes, and impairment of function results.

When the hypertrophic process changes to the hyperplastic variety the newly deposited connective tissue becomes transformed, its cellular elements disappear, and are replaced by a dense fibrous tissue, which by contraction increases the tension in the ossicular chain.

As to changes occurring in the labyrinth from the process within the middle ear, these may depend upon the pressure to which the labyrinthine fluid is subjected from the increased tension, although this factor exists in the early stages only. Labyrinthine complications are not common in the hypertrophic form. The most prominent element in their causation is the interference with the labyrinthine circulation. Although the communication between the tympanic and labyrinthine vessels is not intimate, hypertrophic changes within the middle ear exert an influence probably upon the parts from which they are separated only by the thin membrane of the round window and by the fibres of the annular ligament in the fenestra ovalis. A large portion of the venous blood from the labyrinth enters the general circulation through the vena aquæductus cochleæ, which leaves the labyrinth close to the round window. Hence any increased vascularity within the tympanum affects the venous flow through this after establishing free drainage through the meatus, in applying the ice-coil to the mastoid for a period of thirty-six, and possibly for a period of forty-eight hours, but certainly for no longer time. At the end of this time the ice-coil should be removed and should not be reapplied. Any beneficial effects which will result from the local application of cold will have been obtained at the end of thirty-six to forty-eight hours. If tenderness persists after the use of cold for this length of time, no further abortive measures should be attempted, but the surgeon should enter the mastoid at once. In doubtful cases the otologist is perfectly justified in exposing the mastoid antrum for exploratory purposes. Under proper aseptic precautions, no harm can result from this operation, and early interference may save the patient a prolonged convalescence following a more severe operative procedure. I can hardly speak favorably of local bloodletting over the mastoid region. Occasionally it may be followed by relief; but my experience has been that, where blood has been abstracted from this region, the symptoms have been delayed only, but the complication has not been prevented. Another objection to local bloodletting lies in the fact that the tenderness of the parts to which the measure gives rise may mask that due to the inflammation of the osseous structures. This is not a serious objection, to be sure, and a little care on the part of the surgeon will enable him to distinguish between superficial and deep tenderness. At the same time it is important for us to recognize the fact of mastoid involvement as soon as it takes place, and not delay prompt interference. Any measures which temporarily relieve the symptoms, or cause the disease to progress more slowly, are of a decided disadvantage, and often a menace to life. The particular operative measures to be adopted when the mastoid is involved will be fully described in the section devoted to surgery. It should be stated here, however, that the author is decidedly averse to the employment of a simple incision over the mastoid in these cases. The value of the so-called "Wilde's incision" depends upon the depletion and a certain amount of relief to tension secured by division of the periosteum. The operation is exceedingly painful, and a general anæsthetic is usually necessary. In all cases where the Wilde incision is positively demanded it will probably be necessary to enter the mastoid at a later period; and to give the patient an anæsthetic upon one day for the purpose of making a superficial incision, ously described as singing, hissing, blowing, or whistling sounds. These subjective noises may be entirely drowned by external sounds. Thus they may disappear in a railway train or on a busy thoroughfare, but reappear instantly in a quiet room. In the same way external noises affect the hearing to a marked degree. Most of these patients are able to hear better in a noise than where it is quiet. We may explain this fact either upon the hypothesis that the more intense sounds serve to set the ossicular chain in vibration, after which sounds of less intensity are able to so modify this motion as to be perceived, although they are unable to overcome intratympanic rigidity by themselves, or that loud sounds produce a condition of auditory hyperæsthesia.

Where fluid is present in the middle ear, bubbling sounds may be complained of upon forcible attempts at clearing the nostrils. Snapping or cracking sounds heard in the ear with each act of deglutition, due either to the separation of the walls of the Eustachian tube at this moment or to the entrance of air into the tympanum, is also a symptom often met with. Occasionally we may elicit the fact that upon changing the position of the head the hearing becomes suddenly impaired. This is frequently due to the presence of fluid within the tympanic cavity, the change in position causing it to gravitate to the region of the oval and round windows, and thus to impede the vibration of the labyrinthine fluid. Occasionally slight vertigo is complained of. This, however, is not severe, and is usually attributable to a sudden change in intratympanic pressure, as by auto-inflation, in the act of blowing the nose, aspiration of the tympanum by a sudden deep inspiration, etc. In some cases, however, vertigo constitutes one of the chief symptoms of which the patient complains. The vertigo is then due either to a narrowing of the Eustachian tube or to adhesions about the round or oval window which interfere with the normal labyrinthine pressure.

Pain is not common in these cases, although, when a sudden stenosis of the tube occurs, the patient may complain of occasional neuralgic pains radiating from the pharynx in the direction of the ear. In certain rare instances, where the chronic inflammation is confined mostly to the region of the Eustachian tube, the patient may complain of sharp pain in the throat, referred to the region of the lingual tonsil, frequently more severe upon one side. It is impossible for the patient to locate the exact painful point, although frequently it is referred to the posterior pharyngeal folds or to the lymph tissue at the base of the tongue. In a large number of these cases the pharynx is entirely healthy, and the pain is due to the changes in the Eustachian tube. The true nature of the affection is frequently discovered accidentally, or not until changes within the tympanum have become so marked as to demand measures for relief. Most frequently the patient describes the sensation as not amounting to actual pain, but that the throat feels "rough" or "burns." In other cases the pain is intense, rendering deglutition difficult.

Diagnosis.—A. *Physical Examination.*—The appearance presented by the parts varies according to the extent to which the process has advanced. In the early stages, upon inspecting the drum membrane, there may be no deviation from the normal picture. The most frequent change is a moderate degree of depression of the membrana tympani, evidenced by a foreshortening of the manubrium mallei and exaggeration of the posterior fold (Fig. 103). The color of the membrane is either normal, or there may be a slight reddening along the malleus handle and at the supero-posterior border of the membrane, together with a reddish reflex from the internal tympanic wall. This last sign is considered particularly important by Schwartze, as indicative of the fact that the inflammatory process is still active. The lustre of the membrane is usually slightly diminished, while in texture it appears somewhat thicker than normal. This apparent increase in density is usually not general, but is more prominent over certain areas. An appearance which is quite characteristic of the early stages is the rotation of the malleus upon its long axis, which, if the membrane is at the same time retracted, causes the malleus handle to appear narrower than normal. If there is no depression, the rotation may cause the manubrium to appear abnormally wide (Fig. 102). This change in breadth is due to inequalities in tension of the intratympanic ligaments from the inflammatory process, which is more pronounced in certain portions of the cavity than elsewhere. The presence of adhesions or the irregular tumefaction of the membrane prevents displacement of the ossicular chain by rotation of the malleus about the axis band, but acts in such a manner as to

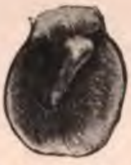


FIG. 102.—Rotation of malleus about its long axis increasing the width of the manubrium.

twist the ossicle about its long axis, turning one of its prismatic surfaces toward the canal. When displacement inward and rotation are both present, a sharp edge of the shaft of the malleus is presented to the meatus, thus making the shaft appear narrow. The short process is usually more prominent and whiter than normal. The position which it assumes gives important information as to the direction in which rotation has taken place, and whether the increased tension lies in the anterior or posterior half of the tympanum. The upper portion of the membrane above the short process frequently has a crumpled appearance due to localized areas of inflammation in the parts beneath. When the disease has existed for some time the membrane in this region may appear abnormally thin, and over the neck of the malleus may be adherent and much depressed. Pressure here may cause atrophy of the fibrous tissue, and may give the membrane the appearance of having been perforated and having undergone cicatrization. In the more advanced cases we find the membrana vibrans displaced toward the promontory, the tip of the malleus frequently impinging upon the wall of the middle ear. It may be drawn either toward the anterior or posterior wall of the tympanum, according to the distribution of the connective tissue within the cavity. When displaced backward and inward, we frequently see a tense band running from the short process downward and backward until it is lost in the posterior margin of the membrane (Fig. 103); so well defined is this that it is frequently mistaken for the handle of the malleus, which lies in front of it, and is only visible when the head of the patient is turned so as to permit the light to be directed beneath this fold. Pomeroy has given the name of "supernumerary posterior fold" to this band.

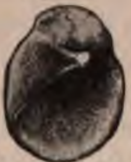


FIG. 103.—Retraction of the drum membrane and adhesions within the middle ear. The malleus handle is narrow, and the supernumerary posterior fold is distinct.

When there is fluid within the tympanum the membrana tympani is apparently crossed by a fine line, which marks the level of the fluid. This appearance is only presented when the drum membrane is not thickened from hypertrophic changes. If this has taken place, the level of the effusion can not be made out, but the segment below the level of the fluid appears more opaque than the part above. The drum membrane over the transudate is of a yellowish tinge, the appearance being more marked if the secretion is inspissated. Occasionally fine bubbles may be seen, appearing as distinct bright points upon the membrana. Any of the above appearances should make us suspect the presence of fluid, and any alteration in the picture after inflation confirms the opinion. If the membrana tympani has remained in contact with the internal wall of the middle ear for a considerable length of time, the pressure may have caused partial absorption of the fibrous layer, increasing the transparency of the membrane in this locality. On the other hand, areas which present evidence of a hypertrophic process are frequently the seat of calcific deposits in the later stages of the disease. The development of adhesions between the membrana vibrans and internal wall of the middle ear is scarcely as characteristic of the hypertrophic variety of the inflammation as of the hyperplastic, yet we may find this condition present, especially in the region of the umbo, as this is the first point of contact between the drum membrane and the external tympanic wall, the displacement being due both to atmospheric pressure and to the action of the tensor tympanic muscle.

In certain cases, especially where frequent auto-inflation has been practiced, the drum membrane becomes much relaxed in the upper and posterior quadrant, and when indrawn applies itself so closely to the bony walls as to permit the intratympanic landmarks in this region, such as the incudo-stapedial articulation and the niche of the round window, to be clearly made out (Fig. 95). Such a relaxation of the membrana is easily demonstrated if we request the patient to inflate the ear by holding the nose, closing the mouth, and blowing forcibly. When this is done the upper and posterior segment will be seen to move outward into the canal, while at the same time the deeper parts disappear from view.

The impairment of hearing in these cases disappears to an astonishing extent when this relaxation is corrected, but may reappear upon deglutition, the air within the middle ear being aspirated and the membrane assuming its former position. The presence of adhesions or the condition of relaxation just described may be satisfactorily demonstrated by alternately rarefying and condensing the air in the meatus by means of the pneumatic otoscope. The adherent areas do not move, while the relaxed portions of the drum membrane are seen to make exaggerated inward and outward excursions, according as the air within the canal is condensed or rarefied.

Anomalies in tension of the intratympanic ligaments are easily demonstrated by the pneumatic otoscope. Under manipulation the malleus handle, instead of moving directly outward when the air within the canal is rarefied, will be seen to twist upon its long axis, the tip of the manubrium frequently remaining fixed, while the short process describes the arc of a circle. Clinically this sign is of importance, as it usually indicates relaxation at the malleo-incudal articulation, and may account for certain subjective symptoms which make their appearance only when the patient changes his position and suddenly separates the articular surfaces of these ossicles.

Inflation by the catheter or air bag—preferably the former—elicits various auscultatory signs. Evidences of fluid within the tympanum have already been mentioned and need not be repeated. When the lumen of the tube is narrowed, the air, upon entering the middle ear, will produce a high-pitched sound on account of the narrowing of the canal. This sound may be either moist or dry, according to the stage of the disease. When the tube is much narrowed and the walls are covered with thick secretion, the air may fail to enter the middle ear, and a distant percussion sound will be recognized with each attempt at inflation, as the air impinges upon the mass of inspissated mucus at the narrow portion of the tube. Prolonged effort will usually dislodge this, after which the air will enter the cavity, causing a sudden outward excursion of the drum membrane, as evidenced by the peculiar sharp click heard as it is driven outward. If the cavity is completely filled with fluid, absolutely no sound may be heard. It is possible for the adhesions to develop in such a manner as to shut off the greater part of the tympanic cavity from the Eustachian tube. When this occurs, the air, as it impinges upon the barrier at the tympanic orifice, will produce a distinct percussion note similar to that heard when an obstruction is present at the isthmus of the tube, but not as remote. Marked relaxation of the drum membrane is recognized by the peculiar flapping sound which is heard as the lax septum is forced outward.

Inspection of the membrane immediately after inflation will enable us to determine over what areas adhesion has taken place between the internal and external tympanic walls.

As before stated, adhesion at the umbo is not uncommon, and hence inflation may produce little change in the position of the membrane, although the hearing may be greatly improved by the operation from the re-establishment of equilibrium.

B. *Functional Examination.*—The hearing power for the voice is considerably reduced. The hearing power for the watch or acoumeter is also diminished. The lower tone limit is elevated, and where the middle ear alone is involved the degree of elevation corresponds to the impairment of audition for the whisper or for the conversational voice. These cases usually hear a whisper relatively better than articulate speech. This is due to the fact that the pitch of the whisper of any given combination of letters is always the same, while in articulate speech the same word or sentence repeated by different individuals varies greatly, owing to the presence of overtones. The individual quality of the voice depends upon these overtones. Hence we find the power of perception for the conversational voice varies greatly according to the individual with whom the patient converses, with some the hearing being but slightly diminished, while with others marked impairment is evident. The upper tone limit is either normal or slightly lowered. Bone conduction is increased in the early stages of the disease, the vibrating tuning fork, placed in the median line, being referred to the poorer ear. In advanced cases it may be referred to the better ear, and when this is the case the prognosis is less favorable. Where the upper tone limit is lowered it not infrequently happens that the greatest deviation from the normal standard is in the better ear. This is explained upon the theory that the increased labyrinthine pressure upon the side first affected has caused certain changes to take place in the cortical area specialized for the perception of these particular notes. This area receives most of its nerve fibres from the ear of the opposite side, but a few come from the organ of the same side. The influence of the tympanic condition upon the labyrinth of the organ first attacked institutes certain cortical changes which affect secondarily the nerve fibres derived from the other ear. These secondary changes expended upon the receptive mechanism are more rapid than the changes within the middle ear; and we find the labyrinthine degeneration on the side last involved more marked than in the organ primarily affected. It is of importance to recognize this fact as indicative of the progress of the disease, and prompt measures must be instituted to curtail the steady advance of the affection.

Prognosis.—The ultimate outcome will depend upon the cause, the social condition of the patient, and the extent to which the process has advanced before the patient comes under observation.

When seen in the early stages associated with affections either of the nasal passages or of the naso-pharynx, we may hope to arrest the disease completely, and in a large measure to correct the damage already done. The station in life occupied by the patient influences the progress of the disease, in so far as it necessitates his exposure to inclement weather, physical hardship, sudden changes of heat and cold, and prolonged mental exertion. The age of the patient is also a factor. Thus, if the impairment of function is considerable in a patient under thirty years of age, we can scarcely hope for great improvement except by the employment of the most radical means at our command; while the same degree of impairment met with later in life would be more amenable to treatment, since at this period hypertrophic changes in the upper air passages are the exception, the tendency being for spontaneous absorption to take place, and the affection might even improve spontaneously. In any given case where the aural lesion is associated with some affection of the upper air passages, we can usually promise, by restoring these parts to their normal state, to relieve the patient of those sudden fluctuations in hearing dependent upon vascular disturbances in the upper air passages. At the same time the progress of the disease will probably be checked, but any marked improvement in hearing can not be promised if the patient is more than thirty years of age, although in many instances the results of treatment are exceedingly satisfactory. In young subjects the changes wrought by thoroughly freeing the upper air passages may cause a retrograde process to take place in the mucous membrane of the tympanum, and great improvement may result. The surgeon must be cautious, however, regarding the extent of improvement promised.

Hygienic measures, the observance of which renders the patient less liable to colds, must also be considered. In cases of long standing the prognosis will depend largely upon the presence or extent of secondary labyrinthine involvement, and particularly upon the degree to which the ear of the opposite side is affected. Any tendency toward secondary sclerotic changes as evidenced by patency of the Eustachian tube, or a degree of patency which is abnormal, will also render the prognosis more grave. The condition of the tube itself is of importance, as it enables us to judge of the changes which have probably taken place in tympanic adhesions. If the tube is of normal calibre it is probable that these have become firm, and that the impairment in function depends upon this cause. We can scarcely hope to absorb a deposit of long standing, and hence our prognosis must be guarded.

Treatment.—We may divide this into the treatment of the upper air passages, the treatment of the Eustachian tube, and the treatment of the intratympanic condition.

Our first care should be to place the upper air passages in such a condition as to permit free nasal respiration, and to prevent as much as possible the venous engorgement of these parts from slight exposure to cold. From this we do not mean that slight deviation from an ideal condition, anatomically speaking, must be dealt with surgically. If the nasal passages are free, and no evidence of mouth breathing is present, the treatment of this region can in no way improve the auditory function. In the same way a small amount of lymphatic tissue within the pharyngeal vault in patients over twenty years of age does not demand removal unless it gives rise to some special disturbance. In young subjects, however, I am disposed to deal radically with any lymphatic hypertrophy in this region if there is the slightest evidence of impairment of hearing, since in early life lymphatic tissue is particularly prone to vascular changes from comparatively slight causes. Adenoid growths, then, should be removed surgically, either by the forceps or curette, or absorption effected by the application of chemical agents. Of these, a solution of the nitrate of silver, introduced through the anterior nares after the parts have been rendered insensitive by cocaine, will be found to be effective. A solution of sixty grains of nitrate of silver to the ounce may be applied to the part by means of the cotton-tipped probe, care being taken not to distribute the solution over the walls of the nasal cavity, nor to use it so freely as to allow it to pass into the lower pharynx. Hypertrophy of the turbinated bodies, if excessive, may be dealt with surgically, but usually cauterization with chromic acid will be sufficient. Obstructive lesions due to deformity of the septum may be removed either with the saw, trephine, or galvano-cautery, as the operator deems most expedient.

Concerning the removal of the faucial tonsils, it is my belief that they may cause secondary engorgement within the naso-pharynx, and hence, if they are hypertrophied, their removal is indicated when met with in childhood or early adult life. After this period this rule naturally does not apply.

The Eustachian canal usually requires special measures to determine its return to the normal degree of patency. Where the obstruction depends merely upon venous engorgement or œdema, attention to the upper air passages, together with inflation of the middle ear with air, will be effective without any other measures directed to the tube. The beneficial effect of inflation upon the calibre of the Eustachian canal depends upon the fact that when the normal calibre is restored for a short time by the passage of a current of air which temporarily relieves the engorgement, it gradually regains its normal patency. The air douche drives the blood out of the distended venous channels and permits them to resume their normal tone, in much the same manner as an elastic bandage relieves venous engorgement of the extremities. If, however, actual hypertrophy has taken place, stimulation of the mucous membrane may be necessary in order to effect restoration. This is particularly true in instances in which excessive secretion is present. The pharyngeal orifice of the tube is the part first affected, and the changes are most marked in this region. Before attempting any local medication, the mucous membrane must be thoroughly cleansed from adherent secretion, otherwise our application will have but little effect. This may be done by washing out the pharyngeal orifice of the tube with an alkaline solution, such as a weak solution of bicarbonate of soda, or the ordinary Dobell's fluid, or a solution of boric acid of about twenty grains to the ounce, to which may be added half a drachm of Listerine. This cleansing is effected by employing a device which consists of a Eustachian catheter the extremity of which is closed, while the curved portion of the instrument is supplied with lateral perforations. Fluid injected through this instrument does not enter the lumen of the tube, although the trumpet-shaped orifice is thoroughly washed and freed from any tenacious secretion. The solution may be injected by means of a common ear syringe inserted into the outer end of the instrument, or the syringe may be provided with a conical tip which fits it exactly. The mouth of the tube may also be cleansed by wiping it out with a pledget of cotton, the applicator being curved like the Eustachian catheter. After thoroughly cleansing the pharyngeal orifice of the tube, it should be touched with an astringent solution. A solution of nitrate of silver, ten to thirty grains to the ounce, is the application most used. In older cases the application of equal parts of compound tincture of iodine and glycerin is efficient. Even where the tube is involved for a considerable distance beyond its pharyngeal aperture, treatment of this region may cause absorption of the newly deposited tissue. If this fails, applications may be made to the entire length of the canal, either by means of stimulating vapors or of medicinal solutions. The precise manner of carrying out these measures has already been given. Dilatation of the Eustachian canal by bougies is exceedingly efficacious where the deposit is of long standing, the mechanical stimulation due to the presence of the instrument within the lumen of the tube causing absorption of the new-formed tissue. If the walls of the tube seem much relaxed and the obstruction recurs quickly, although the tube may admit the passage of a bougie of considerable size, it is well to leave the instrument in position for several minutes to restore the normal tone of the tissues. Medicated bougies may be used, but their employment is difficult, and presents no advantages over topical applications made in the manner described under tubal congestion.

Although the tympanic portion of the Eustachian canal is inclosed in firm, bony walls, it should always be remembered that an obstruction may lie at the tympanic orifice of the tube; and although we can not dilate the osseous canal, we may overcome an obstruction in the locality above named, and should never fail to pass the instrument through the entire length of the canal until the tympanic cavity is entered. Relaxation of the mucous lining may occur even in this region, and topical applications may be beneficial. In many instances an inspection of the membrana tympani will reveal the bougie in the tympanic cavity. It usually lies behind and a little below the short process of the malleus, and by pressure can be made to push the drum membrane over it outward into the canal.

In place of the simple device recommended under "Tubal Congestion," for effecting dilatation of the Eustachian tube, very satisfactory results may be obtained by the electrolytic method, so strongly advocated by Dr. Duel.* By means of this method the swollen membrane of the Eustachian tube is restored to its normal condition through the influence of the galvanic current, the negative pole of the battery being applied directly to the inflamed tissues, while the positive pole is applied to some neutral point. In order to carry out this plan effectually, it is necessary to insulate the catheter through which the bougie is passed, to prevent the current from short-circuiting, and also in order that the full force of the current may be applied directly to the swollen and inflamed membrane. This is effected by winding an ordinary silver Eustachian catheter with a thin strip of rubber tissue, thus forming an insulating coating. An olive-tipped metal bougie, preferably made of gold, is then passed through the Eustachian catheter, in exactly the same manner as has been already described in explaining the technique of the simple method. This metallic bougie is connected by means of a cord with the negative pole of the galvanic battery. The positive pole of the battery is applied at some neutral point by means of the flat sponge electrode, the palm of the patient being usually selected as the point of its application. The catheter is introduced in the ordinary manner and the metallic bougie passed into the tube until an obstruction is met with. The galvanic current is then slowly turned on, being controlled by a delicate rheostat, until the milliampèremeter registers from three to five milliampères of current. Slow pressure is maintained on the bougie, and after a short interval the instrument will be felt to glide by the obstruction. The instrument is passed in this manner throughout the entire length of the tube until it is felt to enter the middle ear. The surgeon becomes cognizant of this fact by the sensation that the end of the instrument has passed into a large cavity and lies perfectly free. He always recognizes the fact by remembering the length of the Eustachian tube and by observing that the bougie has been passed for the requisite distance to enter the tympanum, under normal conditions. It should be borne in mind that considerable care must be taken in carrying out this plan of treatment. It is seldom wise to use more than five milliampères of current and probably three or four are all that is necessary. The voltage of the current must vary with the body resistance in each individual case. The voltage should never be more than 40, and usually a voltage of 30 is quite sufficient. The galvanic current may be generated either by means of a wet or dry cell battery, or the ordinary direct street current used for illuminating purposes may be utilized. When this current is used, proper caution must be employed to have a correct transforming apparatus for the circuit, so as to be certain that too great a voltage is not obtained. It is also important that the rheostat should be very delicately adjusted in order that it may control the current perfectly.

---

* New York Medical Journal, January 16, 1897.

It is difficult to say whether this form of Eustachian bougie possesses any great advantage over the simpler method described before. The apparatus is certainly complicated and somewhat more difficult to manipulate than is the more simple device. Regarding the permanency of results obtained, after a rather extensive experience with both methods, I am not convinced that the results which follow the employment of the electrolytic method are more permanent than those which result from the use of the simple bougie.

The injection of fluids into the tube and tympanum is never wise. It is true that excellent results have occasionally been obtained by this means, but the same object may be accomplished without subjecting the patient to the serious possibilities which the injection of fluid into the tube entails.

The changes within the tympanum may consist of an accumulation of fluid, localized or diffuse hypertrophic changes, and adhesions. When fluid is present, its removal should be effected through the Eustachian tube if possible. To this end, the operation of inflation should be performed with the head of the patient inclined a little forward and toward the opposite side; the current of air, upon entering the tympanum, will then force the fluid through the Eustachian tube into the pharyngeal vault. When this takes place, the sound heard upon auscultation changes in character from that characteristic of fluid within the tympanum to the harsh, bubbling sounds which are indicative of secretion at the pharyngeal orifice of the canal. Subsequently auscultation reveals an entire absence of bubbling sounds as the air enters the cavity. When removed in this manner, the effusion is apt to accumulate a second time. To prevent this, it is wise to follow the simple inflation with the introduction of a medicated vapor into the middle ear. The vapor of compound tincture of benzoin, of eucalyptus, menthol, alcohol, ether, iodine, or any other volatile drug which possesses mild stimulating properties may be used. The length of time during which the application shall be continued will depend upon the effect produced; the degree of irritation should not be sufficient to amount to actual pain, and the patient should be conscious of but a moderate stinging sensation as the current enters the tympanum. If the fluid accumulates a second time, or if our efforts at evacuation through the tube are not successful, the membrana tympani must be incised. Only very general rules can be given as to the proper point of locating the incision, since the fluid may be encapsulated in some of the reduplications of the lining membrane. If the entire cavity is filled, however, it is best to make the incision in the posterior quadrant, dividing the membrane from a point just below the posterior fold to the inferior pole, the line of section running parallel to the peripheral attachment of the membrane. This incision may seem unnecessarily free, but the results obtained are much better than where a small opening is made, since a large opening permits complete evacuation of the fluid, and the parts heal within a few hours, with the development of no cicatricial tissue. A small opening remains patent for a longer period and is closed by a deposit of cicatricial tissue, and the tension of the drum membrane is altered.

After the membrana tympani has been incised certain measures may be necessary to cause the lining membrane of the middle ear to return to a perfectly normal condition, and thus prevent the reaccumulation of the fluid. These measures consist in the instillation of astringent solutions through the opening made, or their injection through the Eustachian tube. The former method is decidedly preferable, since the results obtained are equally good and the discomfort to the patient is much less. In certain instances a small amount of fluid remains in the cavity after the greater portion has been absorbed; this remnant becomes inspissated and adheres closely to the lining membrane of the middle ear. Inflation of the tympanum fails to remove the collection either on acount of its viscidity, or owing to the fact that it lies out of the direct air current. Under these conditions the tympanum should be thoroughly washed out with boiled water or with Thiersch's solution. This lavage may be carried out either through the Eustachian tube or through an artificial opening in the membrana tympani. Where the object is to cleanse the cavity rather than to medicate its lining membrane, irrigation through the Eustachian tube is preferable, since all the recesses of the cavity are reached in this way and a considerable quantity of fluid may be used in irrigation. In carrying out this procedure the catheter should possess a rather sharp curve, and the curved portion should be somewhat longer than where the instrument is used for inflation simply. It should be of such size as to permit its entrance into the Eustachian tube for a considerable distance. Very little force should be used in injecting the fluid through the tube into the middle ear. The injection may be made either with the common syringe or with a fountain syringe, the reservoir being raised to such a level as to permit the current to pass slowly. In this way any inspissated material is removed and the cavity thoroughly cleansed. If proper aseptic precautions have been observed, the wound in the membrana tympani closes within thirty-six hours and usually reaccumulation does not take place, while the improvement in function is frequently considerable. It must be stated that although paracentesis affords a simple and efficient means of disposing of fluid within the tympanum, the collection is exceedingly liable to reaccumulate. When this occurs in individuals beyond fifty years of age it is unwise to attempt any radical measures to prevent reaccumulation of fluid. Incision of the membrana tympani in these cases is not painful and affords complete relief for periods varying from a few weeks to several months. In advanced age the reparative processes of the body are decidedly below the normal standard, and very slight causes easily excite a middle-ear inflammation. Our efforts, therefore, should aim rather to relieve these cases by successive operations than to attempt permanently to cure the affection by means which may result in a serious middle-ear inflammation.

Under the impression that the continued pressure of the manubrium mallei upon the internal wall of the middle ear acted as an exciting cause of the inflammatory process, and that the maintenance of the malleus in this abnormal position was due largely to shortening of the tensor tympani tendon, Weber-Liel * advocated the operation of tenotomy of this muscle in these cases. If we could separate cases in which the inflammatory process depended entirely upon the spastic contraction of the tensor tympani muscle there is but little doubt

---

* Monatsschr. für Ohrenheilk., 1868, Nos. 4 and 12.

that section of the tendon would be followed by complete cure. Unfortunately, we have no means of recognizing the fact that the process is so limited in extent, and experience teaches that by the time the tendon is permanently shortened other portions of the middle ear have become affected. The relief obtained by the operation was demonstrated by an improvement in the ear operated upon and also by a decided improvement in the organ of the opposite side, and both Weber-Liel and later Cholewa * have urged the advisability of the procedure for the purpose of preventing the extension of disease to the opposite ear. The only fault that can be found with the procedure is that it is not radical enough, as it corrects the increase in tension at but one point in the ossicular chain. The tendon of the tensor tympani may be the locality in which the fibrous changes first manifest themselves; but, before this condition is recognized, a diffuse hypertrophic process has involved a large portion of the membrane lining of the middle ear. It is our duty, then, to attempt the correction of this condition as well as to direct our measures toward the contracted tendon of the tensor.

In order that the mucous membrane of the tympanum may resume its normal condition after hypertrophic changes have once taken place, it is necessary to increase temporarily the blood supply of the part; in other words, to create artificially a moderately acute inflammatory process. The most convenient method of effecting this change is to introduce some stimulating vapor through the Eustachian tube into the middle ear in the manner described, at the same time removing all secondary causes which tend to increase the congestion of the tympanic lining. Stimulation by means of fluids injected into the cavity should not be undertaken unless an opening has been previously made in the membrana tympani. If in any given case it seems advisable to inject fluid into the middle ear, care must be taken that the instruments employed in the operation, as well as the fluid itself, have been thoroughly sterilized by heat. I am decidedly in favor, where it is necessary to use fluids in this manner, to introduce them into the tympanum through an opening made in the membrana tympani for the purpose.

The choice of medicated vapors in any given case will de-

---

* Arch. of Otol., vol. xix, p. 151.

pend upon the rules given for their selection for a similar condition of the Eustachian tube in acute cases. If it seems wise to make use of drugs in solution, we should begin at first with weak solutions, such as a solution of zinc chloride, two grains to the ounce; zinc sulphate, ten grains to the ounce; or nitrate of silver, ten grains to the ounce. The strength of the solution may be increased until the desired effect is obtained. The fluid is introduced through the opening in the membrana tympani by means of the middle-ear syringe (shown in Fig. 99), or by the middle-ear pipette. My experience has been that where the process has advanced so far that the introduction of vapors does not produce the desired effect, no benefit is gained by the injection of fluids.

Passive motion for securing greater mobility in the ossicular chain by stretching the newly deposited tissue is not indicated here, as when the disease is in this hypertrophic stage it constitutes an active inflammatory process, which may be aggravated by mechanical irritation. The amount of motion imparted to the ossicles by catheter inflation preserves their motility sufficiently without the employment of other measures in this direction. Where the tension of the ossicular chain is relaxed, great improvement sometimes follows the use of an artificial support, as first suggested by Blake.* This may consist of a small pledget of cotton inserted in front of the short process of the malleus so as to press upon it, crowding the ossicle backward and inward, or a narrow strip of thin rubber may be used, the ends of the strip being brought together and grasped in the forceps, and carried into the canal so that the convexity of the fold in the strip of rubber rests against the short process. Upon removing the forceps the ends of the rubber separate, impinging upon the anterior and posterior walls of the canal, while the convex surface of the strip presses against the short process of the malleus and crowds the ossicle against the incus.

Failing to check the progress of the disease by any of the above measures, or in cases of long standing in which sclerotic changes are beginning to take place, as evidenced by marked retraction of the membrana tympani, exaggeration of the posterior fold, and the presence of atrophic areas in the drum membrane itself, resort must be had to surgical measures.

---

* Arch. of Otol., vol. xxi, p. 166.

These comprise tenotomy of the tensor tympani, as already mentioned, division of an exaggerated posterior fold (plicotomy), section of intratympanic adhesions binding the ossicles to each other or to the tympanic wall, or separation of the drum membrane from the internal wall of the middle ear, to which it may have adhered; all are of value in special cases. The only objection to them lies in the fact that the lesion is seldom limited to one particular region. The evidence of increased tension within the conducting chain is unmistakable, but in almost all cases the entire conducting chain is involved, and not one particular portion.

Where the membrana tympani alone is the seat of the obstruction the establishment of an opening through the drum membrane is beneficial. Its permanency was long ago shown to be the exception rather than the rule, however. If the membrane is relaxed, its tension may be corrected by applying a disk of thin paper over the relaxed area. If the paper disk is moistened before it is applied it will maintain its position upon drying. My own practice has been, whenever impairment of function has seemed to depend entirely upon a middle-ear lesion, and when satisfactory improvement has not been obtained by the employment of measures detailed above, to remove the membrana tympani, malleus, and incus, and to divide subsequently adhesions about the stapes and about the round window. The membrane may be reproduced, but the septum thus formed is thin, comparatively insensitive, and possesses but slight vitality. Its removal is easily effected a second time, or even a third time if necessary, after which a permanent opening usually remains. The chief value of the procedure lies in the fact that it enables us to free the stapes from adhesions which may subsequently develop and be a source of serious functional impairment.

The subject of surgical interference in these cases and the technique of the various operations is considered in the section devoted to the operative surgery of the middle ear.

CHRONIC HYPERPLASTIC OTITIS MEDIA.

Ætiology.—The hyperplastic form of tympanic inflammation may develop from the form described in the preceding section; rarely it follows a purulent otitis media; it may also occur as an idiopathic affection. The cases belonging to the idiopathic group may follow a severe illness, physical or mental exhaustion, and malnutrition. They may depend upon interference with the trophic nerve supply of the middle ear. Sex exerts a certain influence, females being more frequently attacked than males, from which we assume that exposure plays but little part in the causation of the affection. A severe mental shock, such as fright, may exert a causative influence in the disease under consideration. The influence exerted by any abnormal condition in the upper air passages is usually of but slight importance except in those cases which follow the hypertrophic form of inflammation. The disease may attack both ears, or the organ of but one side may be affected. When the condition is present upon both sides the organ last affected may become involved only after many years, and it frequently happens that patients do not discover any impairment of hearing until the previously healthy ear is affected, when examination reveals marked impairment in the hearing power of the opposite side. The affection is to an extent hereditary, especially in those cases of neuropathic origin, although this factor in causation is probably much overrated. Hyperplastic inflammation of the middle ear is most common between the ages of forty and fifty, although it may develop in early adult life, or even in childhood. Its development in advanced age is rare.

Pathology.—The changes which the mucous membrane undergoes have already been touched upon. They consist of an increase of fibrous tissue in the mucous membrane lining the tympanum, which becomes firm and dense in consistency and less vascular. The augmentation of the fibrous elements causes atrophy of the glandular structures and diminished secretion results. As the tissues undergo this fibrous metamorphosis they become dense, and the normal ligaments which support the ossicles within the middle ear and which bind them to one another are shortened. In addition to these changes in the lining membrane, a certain amount of new tissue is deposited, forming bands of adhesions between the ossicles and the internal wall of the tympanum, displacing the ossicular chain and binding it firmly to the osseous walls of the middle ear. The membrana tympani is usually unchanged in the early stages, but by stretching may become atrophic in places, or by prolonged contact with the internal wall of the tympanum may become adherent to it. The hyperplastic changes are usually more marked in the region of the oval or the round window, in the former position binding the stapes firmly in the pelvis ovalis;

while occurring in the latter locality they prevent free oscillation of the membrana tympani secundaria. When the stapedio-vestibular ligament is involved, the foot plate becomes firmly fixed in the foramen ovale, and in cases of long standing bony sclerosis may occur. The tendon of the stapedius muscle with the mucous folds which commonly invest it undergoes shortening, causing displacement and fixation of the stapes, the posterior crus being drawn toward the adjacent wall of the oval niche, to which it contracts adhesions. All of these changes about the oval and round windows may occur without displacement of the membrana tympani, or without giving rise to any changes discoverable upon ocular inspection.

When the upper part of the cavity is much involved, the entire ossicular chain is frequently displaced inward, diminishing the breadth of the tympanic cavity without rotation of the ossicles about the axis band. In other cases the fibres may be so disposed as to draw the tip of the manubrium inward, exaggerating the anterior and posterior folds and giving rise to a picture similar to that seen when the Eustachian tube is closed, the handle of the malleus lying almost horizontal, the short process being prominent.

The changes may involve the upper part of the cavity primarily, and lead to rotation of the malleus about its long axis, increasing or diminishing its apparent breadth, as observed in speculum examination. A process sclerotic from the first does not give rise to the crumpled appearance in the membrana flaccida mentioned in the preceding chapter; this condition, according to Walb,* is characteristic of a secondary sclerosis following hypertrophic changes. The same may be said in general of most of the changes recognizable in otoscopic examination, marked displacement of the ossicular chain usually indicating a preceding hypertrophic process.

The inflammatory process is not limited to connective tissue alone, but may involve the osseous structures as well. When this occurs the shaft of the malleus may present irregularities due to localized periostitis.

Labyrinthine involvement of various grades may occur even in the early stages. It may be so slight as to escape notice or in advanced cases so extensive as to play an important part in the impairment and perversion of the function. When both ears are affected the labyrinthine involvement is frequently more marked upon the side last involved.

---

* Schwartze, Handb. der Ohrenheilk., Leipzig, 1893, vol. ii, p. 198.

The changes occurring in the Eustachian tube result in an undue patency of the canal; this condition exposes the parts within the tympanum to traumatism from violent efforts at coughing, sneezing, or clearing the nose. The tubal muscles are also involved, becoming atrophic quite early in the course of the disease.

Otosclerosis, Rarefying Osteitis of the Labyrinthine Capsule.—In addition to the secondary changes in the labyrinth, such as fixation of the head and foot plate of the stapes, consequent to middle-ear changes, we sometimes find changes occurring in the bony labyrinth, with little or no change in the middle ear. These changes in the labyrinth consist in the development of new osseous tissue within it, usually in the vicinity of either the oval or the round window. The process constitutes a true osteitis. The new bony deposit may either be in the vestibule—that is, beyond the foot plate of the stapes—or it may be in the stapedio-vestibular ligament, or may invade the foot plate of the stapes, the ligament and the oval window itself. Sometimes these deposits occur in the region of the round window, almost completely closing this opening. In some instances, where this condition is present, the drum membrane may present absolutely no deviation from the normal standard. The Eustachian tube is entirely patent, and both ocular inspection and auscultation reveal nothing abnormal about the middle ear.

Symptomatology.—In the early stages the affection is so insidious that considerable damage occurs before the attention of the patient is directed to the ears. Subjective noises are present in a large number of instances, and often cause more distress than the impairment of hearing. They appear early in the affection, as a rule, and increase in severity as the disease progresses. Slight attacks of giddiness may also occur in the early stages, but are usually attributed by the patient to a disturbance of digestion or to some irregularity in the habit of life. The impairment in hearing is at first moderate, and its advance is so gradual as not to be noticed by the patient until both organs are involved, or until one is seriously affected. Pain of neuralgic type and intermittent in character is occasionally present in these cases. The attacks of pain are usually of but short duration, the patient complaining that several times during the day there has been a sudden sharp pain in the throat radiating toward the ear. Occasionally a dull headache referred to the orbital region of one or both sides is complained of. This is apt to persist for a considerable length of time, and the patient feels entirely unfitted for any kind of mental or physical labor, the entire sensorium being to an extent blunted. This dull mental condition causes considerable depression, which in turn aggravates both the impairment in function and the distress caused by the tinnitus. As the result of this impairment of the general nervous tone, the condition of the patient may approach that seen in melancholia, and in certain instances the patient may develop a suicidal mania and attempt to take his own life rather than bear the distress which the tinnitus occasions. The perverted mental condition affects the general nutrition of the body, and the patient loses flesh, becomes anæmic, and to all appearances is suffering from some severe constitutional malady, producing pronounced neurasthenic symptoms.

In the more advanced stages the impairment of hearing is of a somewhat peculiar type, in that it undergoes marked changes from no other assignable cause than the effort made by the patient to understand conversation. When attention is not particularly drawn to the fact that the power of audition is being tested, the hearing may be fairly good; the moment, however, the patient is conscious that a test is being made of his ability to hear certain sounds, the impairment increases to a marked degree, and words which a few moments before have been understood perfectly well are not heard. The facies which these patients present is somewhat characteristic, being indicative of intense mental strain, due probably to their efforts to conceal their affliction.

It must be admitted also that the constant effort to hear which these patients exert is responsible for the condition of impaired nervous tone from which they suffer. The fatigue of the higher centres from this constant strain can not fail to exert a profound influence upon the nerve elements and lead to nerve exhaustion.

A curious mental perversion which many exhibit, in addition to the depression of spirits already spoken of, is the feeling of suspicion with which they regard even their most intimate acquaintances. As they can not understand general conversation, the patients in whom the neurotic tendency is pronounced seem to feel that any remark made in a low tone refers to their condition and is a direct reflection upon them. For this reason many become averse to performing their social duties and isolate themselves as completely as possible. It is hardly necessary to state that this action tends rather to increase than to relieve the functional impairment.

After the disease has persisted for a long time the tinnitus, which was at first distressing, may become less marked, or may disappear completely. When both ears are involved, the tinnitus is often more severe upon the side last affected. This is undoubtedly due to the fact that labyrinthine changes upon the side primarily affected have gone on to such a degree that the portion of the labyrinth which normally responds to sounds similar in character to the tinnitus from which they formerly suffered has been completely exhausted, and no longer reacts to stimulation due to increased pressure.

Diagnosis.—A. *Physical.*—These cases present, upon examination, appearances which vary widely, according to the course which the affection has pursued. When the process has been sclerotic from the first, the ear may present no changes upon inspection. The position of the light reflex may be normal; the lustre of the membrane may be preserved; the density may be uniform, and no deviation from the normal position may be recognizable. Under these conditions we are usually correct in assuming that the process has been of the hyperplastic type from its incipiency, and that the deposit of fibrous tissue has taken place chiefly about the oval and round windows. Occasionally inspection of the inner extremity of the osseous meatus will reveal a slight change in color, the cutis being of a somewhat pinkish tinge. This is indicative of the presence of an inflammatory process within the tympanic cavity, and shows that the disease is still in an active stage. Where the membrana tympani has become slightly atrophic we may observe a similar congestion affecting the inner tympanic wall, which imparts a slightly pinkish tinge to the otherwise normal membrana tympani. The thinning of the membrana, particularly of the upper and posterior segment, may enable us to see the long process of the incus, the incudo-stapedial articulation, and stapedius tendon in their normal position (Fig. 95). In other instances we may have slight sinking inward of the membrana tympani, with rotation of the malleus about its long axis. If rotation has occurred from behind forward, the shaft of the malleus appears somewhat broader than normal, and of a dead-white color (Fig. 102). This change in color is due to atrophic changes in the overlying fibrous layer. When rotation takes place in the opposite direction we usually have considerable retraction of the membrana tympani, exaggeration of the anterior and posterior folds, and the fundus of the canal assumes a more circular contour (Fig. 104). In these cases a sharp edge of the prismatic shaft of the manubrium is presented to view, which causes the shaft to appear narrower than normal. In cases of long standing, especially if met with in advanced life, the inflammatory process may have induced certain changes in the periosteal covering of the manubrium mallei, as the result of which irregularities in outline appear upon the shaft. These are really calcific deposits in this periosteal covering, and are worthy of note, as they suggest the possibility of similar deposits within the tympanic cavity in the neighborhood of the oval or round window. Where the degree of depression of the drum membrane is considerable the process has usually supervened upon preceding hypertrophic changes. The increased tension to which the membrana tympani has been subjected has resulted in an attenuation of its fibrous layer, and inspection of the underlying intratympanic parts is possible. In addition to these changes, it is not uncommon to find the drum membrane adherent in places to the inner wall of the tympanum, particularly at the umbo. The position of the light reflex varies with the degree of inclination of the membrana to the walls of the canal, but is of little diagnostic importance. As mentioned before, changes in the membrana flaccida are of diagnostic importance in determining the development of disease upon a preceding hypertrophic process. When this has occurred, the membrana flaccida presents a crumpled appearance, and may be adherent to the neck of the malleus. In cases that have been hyperplastic from the start Shrapnell's membrane presents no such changes, but preserves its normal conformation, although its color may be slightly lighter than in health. Deposits of lime salts in the membrana tympani are seldom seen, although, when the condition is met with in advanced life, such deposit may be present along the annulus tympanicus.

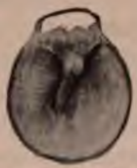


FIG. 104.—Moderate retraction of the drum membrane and slight narrowing of the malleus handle from rotation.

B. *Functional Examination.*—The hearing power is diminished to a varying degree for both whispered and spoken words. The degree of impairment for sharp noises, such as the tick of a watch or the sound of an acoumeter, varies with the amount of labyrinthine involvement present, and hence constitutes an unsafe test for estimating the power of audition when the case first comes under examination, or subsequently for determination of the improvement which has followed as the result of treatment. Quite frequently the hearing power for the watch and the voice will be disproportionate. The watch may not be heard at all, while spoken or whispered words may be heard for a considerable distance, and the patient may consider this ear better than its fellow, although upon the opposite side the watch may be heard at a considerable distance, while the voice can not be understood as well as on the other side. This depends upon the fact that the labyrinthine changes impair the hearing for sharp sounds, such as the tick of a watch, since these lie in the upper portion of the musical scale, while that portion of the musical register which is made use of in conversation lies in the lower portion of the scale, and may be perceived, although considerable labyrinthine involvement is present. Interference with the conducting mechanism, on the other hand, impairs the hearing first for the lower notes, and hence conversation is heard more poorly in the ear possessing the most marked tympanic involvement.

The lower tone limit is considerably elevated. Bone conduction is increased where the changes are confined to the middle ear. The fork placed upon the vertex is referred to the poorer ear provided only middle-ear changes have taken place, but where serious labyrinthine changes have occurred it may be referred to the better ear. This is not invariable, however, for, as already stated in pathology, changes in the perceptive apparatus in the ear last involved often progress with great rapidity, becoming in a short time more extensive than in the organ first affected. When this is the case the vibrating tuning fork applied over the median line of the skull may be referred to the ear which was first affected, although this may be the poorer ear. This should not mislead the examiner into believing that the trouble upon the side to which the fork lateralized is entirely free from labyrinthine trouble. Increased tension in the conducting system may be sufficient to produce this phenomenon, even when the labyrinth is involved to a considerable extent. Absolute bone conduction may vary according to the age of the patient as well as with the degree to which the labyrinth has suffered; hence this test yields but little information. When absolute bone conduction is exaggerated we are justified in assuming that no serious labyrinthine involvement exists. In cases occurring in advanced life, however, the labyrinth may be intact, although sound conduction through the cranial bones is below normal.

Of much more value than absolute bone conduction is the relative duration of sound perception through the solid media as compared with the period during which the same sound is heard through the air. In this manner we are able to estimate with considerable certainty the amount of impairment depending upon the labyrinthine changes, as distinguished from that caused by the intratympanic lesion. In a given case, where whispered words are but poorly perceived, if the reversal of the relation between air and bone conduction exists for a fork making 512 V. D. or for a fork of the next higher octave, we are warranted in assuming that most of the impairment depends upon intratympanic changes. With the same degree of functional impairment, if this reversal should occur only for a fork making 64 V. D., while for the octave above this the air conduction was better than bone conduction, we should assume that serious labyrinthine changes had taken place.

The determination of the upper tone limit is of great value in these cases in confirming the fact that the labyrinth is involved. The first turn of the cochlea perceives the highest notes of the musical scale, and secondary labyrinthine degeneration should be characterized by a lowering of the upper tone limit, as this portion of the cochlea is in the most immediate relation to the middle ear and is the part which suffers first in secondary labyrinthine affection. When functional examination shows a defect at the upper portion of the scale, persisting after anomalous tension has been corrected by inflation, labyrinthine involvement is almost certain. A history of attacks of vertigo is confirmatory of this opinion.

Where we have to deal with a true otosclerosis or osteitis, involving the labyrinth primarily, the differential diagnosis may only be made by observing the case for a considerable period of time, and also by following closely the effects of treatment. The deposit of new bony tissue in the labyrinth in the very early stages gives rise to exactly the same phenomena upon functional examination as does some obstruction to sound conduction in the middle ear. When, however, a careful physical examination shows that the middle ear is apparently normal, and, in spite of this, there is impairment of hearing, with elevation of the lower tone limit, normal or increased bone conduction, and a normal upper tone limit, the surgeon should always suspect the possibility of a beginning primary sclerotic process in the labyrinth. An hereditary history of deafness should always be regarded with suspicion, in cases presenting these symptoms.

Prognosis.—Hyperplastic changes within the tympanum constitute an affection of the gravest character as regards the integrity of function, and one which is less amenable to treatment than all other aural diseases. The usual course is steadily progressive, although the affection may remain quiescent for a long period of years.

Knowing this fact, it is difficult to estimate the value of treatment in any given case, the apparent improvement being possibly due to a period of spontaneous quiescence. When seen in the early stages, and affecting but one side, a fairly favorable prognosis may be given. When both organs are affected it will be impossible to restore either ear to a perfect condition. The most we can hope for is a slight improvement in one or both, and to check permanently the progress of the affection. Aside from treatment, the environment of the patient or the occurrence of any severe illness affects the progress of the aural condition to a marked extent. A severe illness, prolonged physical exertion, overwork, or anxiety—all tend to hasten its advance. From the fact that many cases are of neuropathic origin, particular attention must be paid to the habit of life. All excesses, either of the table or undue indulgence in tobacco or alcohol, should be avoided, and the preservation of a normal condition of the larger viscera and of the primæ viæ must be insisted upon. Climate is a factor in prognosis only to the extent to which it causes impairment of the general health. Since a dry atmosphere and an equable temperature are most conducive to a normal condition of the upper air tract, the disease perhaps progresses less rapidly in regions where these climatic conditions are found. I am inclined to believe, however, that the influence of climate has been much overestimated. The age at which the affection develops may influence its progress. When occurring late in life, its advance is usually slow unless aggravated by some cause, such as a severe intercurrent disease, mental strain, or prolonged physical exertion. Its appearance at the menopause is not uncommon, and our prognosis in incipient cases met with at this period of life should be exceedingly guarded.

Treatment.—The two conditions with which we have to deal are those resulting from the connective-tissue deposit within the tympanum and the secondary labyrinthine changes. The intratympanic condition being one essentially of rigidity of the ossicular chain, our first efforts are to relieve this abnormal tension. When seen early it may be possible to effect absorption of the newly deposited tissue by stimulation of the mucous lining of the tympanum; this is done by inflation by means of the catheter, making use of some of the stimulating vapors already mentioned in the treatment of hypertrophic inflammation. By inflating with considerable force we may be able to rupture recent adhesions and thus relieve the conducting mechanism, or the bands may be stretched sufficiently to permit increased mobility in the ossicular chain. The Eustachian tube seldom requires attention, although the exercise of the tubal muscles, either by gargling or better by massage by means of the Eustachian bougie, may correct the changes which have taken place here. According to some authorities, this massage also exerts a favorable influence upon the tensor tympani muscle and prevents its atrophy and subsequent shortening. To massage the tube in this way the bougie is introduced as far as the isthmus and then moved rapidly inward and outward for a few seconds. Passive motion by means of Siegel's otoscope affords us a means of combating the adhesions. The instrument should be introduced into the meatus, care being taken that it fits the lumen air-tight. The air is then alter-

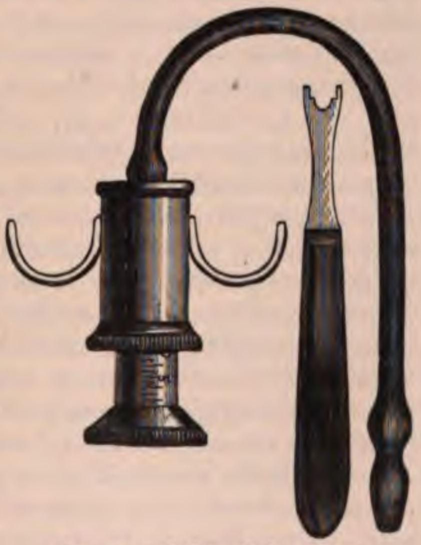


FIG. 105.—Delstanche's masseur.

nately rarefied and condensed in the external auditory canal, imparting to-and-fro movements to the drum membrane and attached ossicula. The masseur of Delstanche (Fig. 105) acts upon the same principle. Cases have been reported where rupture of the membrane has taken place by the violent use of these instruments; this seems hardly probable, however, if even an ordinary amount of care is taken in their manipulation. In the same direction manipulation of the parts at the hands of the patient has been tried, in some cases with success. The method was first devised by Hommel and consists in pressing the tragus backward over the external meatus until this is completely closed, thus condensing the air in the canal. By now alternately increasing and relaxing the pressure upon the tragus the density of the air in the canal is augmented or reduced and the drum membrane made to perform inward and outward excursions.

In a general way, I am rather inclined to believe that the employment of any instrument for the purpose of pneumo-massage is contraindicated in these cases. A little thought will enable us to easily understand that the drum membrane, being the most elastic structure upon which the masseur acts, will be the most easily influenced by changes of pressure within the external auditory meatus. While the object of pneumo-massage is to increase the motility of the ossicles, its real effect, if employed for any length of time, will be to cause a relaxation of the drum membrane, especially in the posterior quadrant. The intratympanic adhesions, consisting as they do of dense bands of connective tissue, will be but little influenced by the rarefaction of air within the canal. The more elastic drum membrane, however, presenting as it does a large surface capable of expanding as the pressure within the tympanum becomes relatively increased, must certainly become stretched if the air within the external auditory meatus is repeatedly rarefied. Any apparatus for pneumo-massage, therefore, can not improve the patient, but must, in very many instances, cause an aggravation of the symptoms. I have been convinced of this by observing the effect of pneumo-massage in quite a number of cases. Massage by Hommel's method will probably do no harm, but it is doubtful whether it ever does any good. I do believe, however, that a certain amount of benefit may be obtained, in rare cases, by a thorough massage of the muscles of the neck overlying the Eustachian tube. The beneficial results secured are probably due to the circulatory changes induced in the mucous membrane lining the tube and middle ear.

The various instruments recommended in these cases for mobilization of the ossicles by "vibratory massage" deserve only a passing notice. Many instruments have been constructed for this purpose and all have failed to produce the improvement desired. In many cases the use of these instruments has been followed by a marked diminution in the power of audition and an increase in the intensity of the subjective noises due to an overstimulation of the auditory nerve.

Politzer has devised a method for maintaining a constant negative pressure in the meatus by the use of a conical plug of cotton which is impregnated with cocoa butter. This plug is inserted into the canal at night, and, in virtue of its oleaginous composition, absorbs the air contained within the meatus, thus causing the membrana tympani to move outward under the action of the air within the middle ear. I have had no personal experience with this plan, but in cases where it has been tried I have failed to see any benefit. It is certainly inferior either to Hommel's method or to systematic manipulation with the Siegel otoscope.

Lucae * has met with considerable success in applying passive motion to the ossicular chain by means of the pressure sound. The device consists of a small tube through which a rod terminating in a cuplike extremity passes. The other end of the rod lies within the tube and rests upon a small spiral spring the tension of which is regulated by a small screw on the handle of the instrument. In use, the cup-shaped extremity is applied to the short process of the malleus, over which it fits, the manipulation being effected under illumination. Pressure inward upon the handle of the instrument is communicated to the ossicular chain, the degree of pressure depending upon the tension of the spring. By pressing the handle of the instrument inward and then relaxing the pressure, the entire ossicular chain is alternately forced inward and then allowed to resume its former position through its own elasticity. It has been demonstrated that pressure exerted at the short process of the malleus is communicated directly through the incus to the foot plate of the stapes, and from this to the labyrinth.

---

* Arch. für Ohrenheilk., vol. xxi, p. 84.

The advantage of the device over an ordinary probe consists in affording us the means of alternately increasing and diminishing this tension without removing the instrument from the short process of the malleus, as its continual reapplication would be attended by considerable pain. In my practice a modified manipulation similar to this has not been attended by favorable results.

The use of the instrument of Lucae is somewhat painful. Many patients, especially in private practice, would object to the measure, and it has never seemed that the results obtained warranted the infliction of so much discomfort. The length of time during which this method of treatment should be carried on must vary with the individual cases.

It has never seemed to me wise to give an absolutely unfavorable prognosis in any case where the lesion was confined mostly to the middle ear without trying the effect of stimulation of the lining membrane by means of vapors for a period of four to six weeks, the inflation being performed at first on alternate days and the interval gradually increased to three or four days. In addition to the inflation, passive motion by means of the Siegel otoscope may be employed, or, if it seems desirable, the use of the pressure sound. At the end of this period, if no improvement results, surgical measures are imperative, and, unless the degree of improvement is considerable, the same advice should be given. During this period the observance of the ordinary hygienic rules should be insisted upon; but attention to the upper air passages is seldom followed by marked improvement, unless there have been symptoms referable to these parts demanding treatment for their relief.

The surgical measures to be adopted in these cases will depend upon the physical condition present. It may be sufficient to divide tense bands which may be seen by ocular inspection, such as an excessive deposit of connective tissue in the posterior fold, or adhesions between the tip of the manubrium and the internal tympanic wall. As mentioned in a preceding chapter, however, it is impossible to assert that the increase in tension is due to the presence of adhesions in any one particular locality. The procedure, therefore, which seems most wise is at first an exploratory myringotomy under strict antiseptic or aseptic precautions. A large flap involving the entire postero-superior segment of the membrana vibrans should be turned downward and forward, the intratympanic structures inspected, and the degree of mobility of the stapes determined by means of a delicate probe introduced through the opening. This procedure can be conducted under cocaine anæsthesia and tests can be made of the hearing at various stages of the operation. Occasionally the artificial opening into the tympanum may improve the hearing power to a remarkable degree; if this does not occur, disarticulation at the incudo-stapedial joint should be the next step. If the stapes is movable, the hearing will now be improved; if this ossicle is fixed, however, but slight improvement will be noticed. The stapes must then be freed by division of the stapedius tendon and of any adhesions lying in the oval niche, in the manner to be described in the chapter on operative procedures within the tympanum. After the adhesions have been severed as completely as possible passive motion should be employed, the stapes being crowded first upward, then downward, then forward, and finally backward by means of a delicate steel probe the extremity of which is protected with a small cotton pledget firmly wound upon it. The condition of the round window should also be investigated and adhesions in this region severed with an angular knife. If the degree of fixation is extreme it may be wise to attempt extraction of the stapes, although the results obtained are not perfectly satisfactory, and the author prefers to remove the malleus, incus, and drum membrane, leaving the stapes in an easily accessible position, so that subsequently mechanical mobilization may be effected if fixation occurs again at any future time. I am aware that this method has been criticised, but it possesses the advantage of freely exposing the parts and enabling us to make successive efforts at freeing the stapes rather than necessitating the completion of all operative interference at the time of the first operation. Certainly in my own practice results have been better where this plan has been followed than where stapedectomy has been performed, and the opening in the drum membrane closed as quickly as possible. The operative technique and the results obtained will be detailed in a later chapter, devoted to the subject of middle-ear operations.

The measures herein enumerated constitute the most efficient means at our disposal for dealing with the intratympanic conditions. When the labyrinth is involved to any extent operative interference is contraindicated, since the cases do not improve after such procedures, but are frequently rendered worse.

The extent of labyrinthine involvement in any given case is determined by the degree to which the upper tone limit is lowered and by discovering the upper limit in the musical scale at which the normal ratio between air and bone conduction is reversed. With a marked lowering of the upper tone limit and an inversion of the ratio between bone and air conduction for the low notes alone, in cases where the impairment of hearing is so marked that whispered words can not be distinguished at a distance of two or three feet from the ear, the labyrinthine feature is so prominent as to positively contraindicate operative interference upon the tympanum. The result of treatment for the labyrinthine affection is usually less favorable than in primary labyrinthine disease. At the same time, we are at least justified in making the attempt to remove the difficulty.

The drug, the administration of which is followed by the best results, is undoubtedly pilocarpine. The physiological action of the drug increases the vascularity of the labyrinthine tissues, at the same time augmenting the activity of the cutaneous and salivary glands. From the increased blood supply any excess of labyrinthine fluid is abstracted from the bony cavity which contains it, entering the general circulation and subsequently being eliminated in the cutaneous or salivary secretions. The increased vascularity may also cause the resorption of newly deposited tissue, provided the deposit is not too old. Formerly the drug was administered by hypodermic injection. This, however, renders it necessary for the patient to give up a considerable portion of each day to the treatment, and in many instances this can not be done. For the last two years I have administered it by the mouth, beginning at first with doses of one eighth to one sixth of a grain two or three times daily, the amount being gradually increased until a moderate physiological effect followed each exhibition. It is only necessary to warn the patient to exercise caution against exposure to draughts for the period of an hour and a half following each administration of the remedy. In those cases where the vocation of the patient necessitates absence from home for the entire day one dose may be administered early in the morning immediately upon rising, while the second may be given upon retiring at night. In this way the patient is able to protect himself sufficiently against undue exposure, and by following this plan no untoward symptoms have resulted. Profuse salivation need not be produced, nor need the cutaneous secretion be increased to such a degree as to be unpleasant. A moderate increase in the moisture of the skin and in the amount of saliva is an evidence that the drug is producing the desired effect, and the patient learns after a short time to so grade the dose as to obtain the desired action. No results can be hoped for unless the plan is persisted in for a considerable period—certainly for two months—at the end of which time, if the slightest improvement is manifested, it should be continued for twice or thrice this period.

According to Kosegarten,* the remedy exerts a beneficial action upon the mucous membrane of the tympanum also, causing an absorption of newly deposited connective tissue. It is possible to observe a congestion of the tympanic lining if the patient is examined one or two hours after the administration of the drug. Politzer advocates the local application of the muriate of pilocarpine to the mucous membrane, a few drops of a two-per-cent solution being injected through the Eustachian catheter. Personally I have no experience with this plan.

In cases of hyperplastic inflammation occurring in advanced life the auditory nerve may be found in a condition of torpor. Here strychnine may be given with advantage, the amount being gradually increased to the full physiological limit. This drug is also valuable in cases with pronounced neurasthenic symptoms. For the relief of distressing tinnitus which persists in spite of all local treatment directed toward the middle ear dilute hydrobromic acid will sometimes be found efficacious. This is to be given well diluted, in doses of thirty minims, three or four times daily. The question of subjective noises will be more fully dealt with under diseases of the perceptive apparatus. The possibility of an hereditary or an acquired specific taint should always be remembered in these cases, and if there is the slightest evidence of such a factor in causation the internal administration of iodide of potassium is advisable. It may be given either alone or in connection with the pilocarpine.

Politzer has derived, apparently, beneficial results from the administration of iodide of potassium, in fairly large doses, in cases where beginning otosclerosis of the labyrinth was suspected, and in which there was no history of hereditary or acquired specific disease. His plan of treatment is to give these patients a course of iodide of potassium for a period of several weeks during each year. While this plan of treatment is worthy of trial, the uncertainty in diagnosis renders the reports far from convincing.

---

* Archives of Otology, vol. xvii, p. 95.

The question of the propriety of treating the middle-ear condition when serious labyrinthine involvement coexists is still unsettled. The results obtained, no doubt, differ in individual cases, but I am sure that the rule is not constant that measures directed to the middle ear invariably aggravate the labyrinthine lesion. Our only guide in the matter is to examine our cases frequently and observe the effect of treatment. If we find that inflation, passive motion, or other measures directed to the tympanic condition, produce giddiness or an increase in the tinnitus, they should certainly not be persisted in. Numerous instances will be met with in which exactly the reverse takes place, the labyrinthine complications improving as the tympanic structures resume a more normal condition. From what has already been said under prognosis, the general condition of the patient must be kept constantly in mind, and care must be taken to tax either his mental or physical powers as little as possible. Attention to the cutaneous, digestive, respiratory, and circulatory organs is imperative if we expect any favorable results from local measures. It is not wise to send these cases from home in the hope of obtaining permanent benefit from a change of climate, as the results obtained by climatic treatment are at the best uncertain.

CHAPTER XXII.

CHRONIC PURULENT OTITIS MEDIA.

Ætiology.—This disease may follow either an acute catarrhal or an acute purulent inflammation of the tympanic cavity. In the former instance it occurs as the result of an infection of the discharge through atmospheric impurities, while as a sequel of the latter condition it represents the failure upon the part of Nature to restore the affected structures to a normal condition. The term is often applied to all cases of aural disease in which the discharge from the middle ear has existed for more than two or three months, or even to cases in which the ear is discharging when the patient presents for treatment. Exactly when an affection ceases to be acute and becomes chronic is hard to determine. For convenience, however, we may assume that a discharge from the middle ear which has failed to yield to proper therapeutic measures at the end of three months constitutes a symptom of a chronic inflammatory process.

A tubercular and occasionally a specific diathesis also may give rise to the affection, the special germs of these diseases finding lodgment in the tympanum and setting up the peculiar inflammatory process characteristic of each. When the disease is of tubercular nature its onset is so insidious that the patient may not be able to state the exact period of its inception, the first knowledge which he has of an aural affection being the appearance of a discharge in the meatus, while examination reveals a condition which could only result from a chronic inflammatory process.

Pathology.—When we find a purulent discharge from the tympanum which has persisted for a long period we are forced to conclude that a certain amount of tissue necrosis has taken place. This is true whether the disease was at first of a catarrhal nature or was purulent from the beginning. The infection of a perfectly innocuous discharge from the tympanum must result in tissue necrosis unless the source of infection is removed at a very early period. Those parts of the tympanic cavity which are richly supplied with connective-tissue elements form an excellent nidus for the development of these germs, and when they are once infected it is practically impossible for us to prevent considerable destruction of tissue. In the early stages the connective tissue alone may be involved, but very soon the osseous structures participate in the process, owing to an interference with their proper blood supply. Those parts are attacked first which are the least vascular and whose nutrient vessels are so situated as to be easily interfered with by any increase in pressure in the tympanic cavity. The blood supply of the incus, it will be remembered, is very limited, and is derived from the petrosal branch of the stylo-mastoid. From its situation its calibre is easily obliterated by any swelling in the upper portion of the tympanum. Hence when the ossicular chain is the seat of necrosis the incus usually suffers first, caries or necrosis of this ossicle being present in eighty-five per cent of all cases in which the ossicles are involved. The process may spread to the walls of the tympanum, usually to that portion of the external wall which is formed by the auditory plate of the temporal. The internal wall of the middle ear is seldom affected, although it may be involved when the condition is tubercular, or in cases following one of acute infectious diseases, such as scarlet fever or diphtheria. Since any profuse discharge from the meatus which has existed for several months must come from the middle ear, it goes without saying that the membrana tympani is perforated in all cases. The amount of local destruction and the particular region where the loss of substance occurs varies greatly. Complete destruction of the drum membrane is rarely seen, although the entire membrana vibrans may be wanting with the exception of the so-called cartilaginous ring, which marks the line of insertion into the annulus tympanicus. When only a small portion of the drum membrane is destroyed the perforation most frequently occurs in the posterior quadrant at the level of the umbo or slightly below it. When the osseous structures are involved and the disease has been of long duration we not infrequently find the perforation located in the upper and posterior quadrant just below the incudo-stapedial articulation. The membrana tympani in these cases is often adherent to the internal wall of the middle ear; its upper margin, however, is free.

and a probe passed beneath this may be directed upward into the tympanic vault, following the long process of the incus. The reason why this perforation is so characteristic of caries within the tympanum depends upon the fact that the avenue of exit for any fluid which has collected lies along the long process of the incus. In fact, this may be the only course which the secretion can follow, as no other portion of the ossicular chain passes from the upper part of this cavity into the atrium. Anteriorly the atrium is shut off from the tympanic vault by the anterior and external ligaments and by the body and neck of the malleus. In addition to these structures, normally present, certain reduplications of mucous membrane are often found, and these may be so numerous and so disposed as to render it impossible for even air to pass from the vault of the tympanum into the cavity beneath. Perforation in this location is so commonly associated with caries of the incus that I have come to regard it as almost pathognomonic of the condition. More rarely we find the perforation located in the membrana flaccida, either just above the short process or above the posterior, or, more rarely, above the anterior ligament. A perforation above the short process always means intratympanic caries, and usually indicates that the malleus is affected, although this rule is not invariable. The extent to which the walls of the tympanum participate in the destructive process varies according to the care which has been exercised in keeping the ear properly cleansed, and the degree of infection which primarily produced the disease. Constitutional diatheses exert a marked influence upon the extent of involvment of the osseous walls; this is particularly true of the tubercular and specific diatheses, the bony parts breaking down rapidly when once local infection has taken place.

Secondary involvement of the labyrinth is seldom met with in chronic suppuration. When present, the mischief has usually been done in the acute stage of the disease, and although both the oval and the round window may have remained bathed in pus for years, extension to the labyrinth seldom follows. This should not be taken to mean that the lower turn of the cochlea is functionally perfect in these chronic cases. It is more reasonable to explain the slight changes found here upon the ground that they are produced by the alteration in pressure at the oval window due to adhesions about the stapes than to attribute the condition to an infection of the labyrinth.

In addition to this mild form of labyrinthine involvement, causing merely impairment of hearing for the upper notes of the musical scale, it must always be borne in mind in every case either of acute or chronic suppuration of the middle ear, that there is a possibility of the extension of the inflammatory process directly to the labyrinth, either through the oval or round windows, or, in the case of chronic suppuration, of erosion of the external wall of the horizontal semicircular canal and propagation of the inflammation to the intralabyrinthine structures through this channel. In many cases, a suppurative inflammation of the labyrinth shows but little tendency to extend and become general. In some cases, however, the entire labyrinth is destroyed by the suppurative process. When this occurs there is always great danger of the inflammatory process extending from the labyrinth to the cranial cavity and causing an involvement either of the dura or of the brain substance itself. The inflammatory process may extend either along the aquæductus vestibuli and aquæductus cochleæ, or may simply follow the sheath of the auditory nerve inward through the internal auditory meatus, the site of intracranial infection being frequently found in this latter region.

Knapp * has reported a case in which extension to the intracranial contents occurred in this manner, giving rise to a purulent meningitis and to a small abscess in the left cerebellar lobe in the region of the flocculus. The occurrence of cerebellar abscess in this case is interesting. Okada † has demonstrated that a large number of cerebellar abscesses follow labyrinthine suppuration. According to the statistics of this author, suppuration of the labyrinth is a more potent cause of cerebellar abscess than is sinus thrombosis.

Secondary involvement of the mastoid process constitutes the most grave complication from which these patients suffer. When drainage through the external canal is free the mastoid is seldom involved. If, however, the outflow through the canal is obstructed, the pus finds its way into the pneumatic spaces of the mastoid, an osteitis is set up, and more or less extensive bony destruction takes place. A change of considerable im-

---

* Archives of Otology, vol. xxxi, p. 99.

† Diagnose und Chirurgie des Otogenen Kleinhirnabscess, Haug's Klinische Vorträge, Jena, 1900.

portance, and one which is always present to a greater or less degree, is a chronic inflammation involving the mastoid. This is essentially a chronic proliferative osteitis, through which the pneumatic spaces are obliterated, and the entire mastoid process becomes converted into dense eburnated bone. This change may be so complete that all the air spaces are obliterated, and the antrum itself may be reduced in size. Only in those cases which have persisted for a long period of years and in which the process has been active is no trace of the antrum found.

The obliteration of the pneumatic structure of the mastoid is of considerable importance from a clinical standpoint. In a pneumatic mastoid an acute exacerbation of the chronic inflammatory process within the middle ear may perhaps result in an infection of the mastoid cells and the development of an acute mastoiditis, with all the signs characteristic of this condition. If, however, the mastoid is sclerotic, and the pneumatic spaces have disappeared and the bone has become sclerosed, an acute inflammation of the tympanum is apt to extend rapidly to the cranial cavity either through the tympanic roof to the middle cranial fossa or through the posterior wall of the mastoid to the lateral sinus or cerebellum.

The development of a cholesteatoma following chronic suppurative otitis depends upon the inflammatory process assuming a particular type, as the result of which the superficial epithelium covering the mucous membrane is formed rapidly and as rapidly desquamated, while the fluid products of inflammation are slight or practically absent. As the result of the casting off of these epithelial cells there are formed, first in the vault of the tympanum, and later in the mastoid itself, irregular masses of epithelium, in which the cells are firmly packed together. This process depends upon the transformation of the superficial epithelium lining the tympanum into epidermal cells. The change is probably due to the extension of the cutaneous lining of the canal into the middle ear through an opening in the membrana tympani. Such a condition follows perforation in Shrapnell's membrane more commonly than a solution of continuity in the membrana vibrans. In some instances these cutaneous cells become completely covered by the mucous membrane and by their proliferation form true cysts containing a mass of desquamated epithelium.

The cases of cholesteatoma met with in which there is no evidence of a previous perforation of the drum membrane are probably the result of an inflammatory process in infancy, at which time the drum membrane was perforated.

The acute symptoms which may be caused by the presence of a cholesteatoma and the treatment of the condition will be considered later. As these masses increase in size slowly but constantly, they dilate the cavity in which they lie, displacing the surrounding walls. The mechanical irritation, due to the presence of the mass, causes a condensation of the osseous tissue, or mastoid sclerosis. Another condition which may result from the development of these epithelial masses is absorption of the bony wall separating the meatus from the mastoid cells, the mastoid cells and external canal being converted into one large cavity. If the bony walls are absorbed in the opposite direction, perforation into the cranial cavity may take place. Products of inflammation may enter the cranial cavity by transmission through the perforating veins or by local necrosis over any given area. According to the location and the exact nature of the local lesion, such an invasion of the cranial cavity may result in an epidural abscess, a diffuse meningitis, a brain abscess, or a sinus thrombosis.

Symptomatology.—The one prominent symptom is, naturally, discharge from the ear, and although extensive destruction may have taken place, this may be the only symptom of which the patient complains. The amount of discharge varies, in some cases being so profuse as to fill the meatus in spite of frequent cleansing; at other times being discoverable only upon inspection of the ear by reflected light, the secretion drying upon the walls of the meatus and never appearing at the orifice of the canal. The degree of impairment of hearing is never indicative of the extent of the local process. It is not uncommon to find the entire membrana vibrans wanting, the incus completely destroyed, and the malleus carious, and yet the power of audition not noticeably impaired. In other cases, where the lesions are less extensive, a high degree of deafness is present. Subjective noises are much less frequently met with in chronic suppuration than in the nonsuppurative form of inflammation. Attacks of vertigo may be complained of, dependent upon no assignable cause, or they may occur only when the ear is syringed. The disturbance of equilibrium may be but slight or so pronounced as to cause the patient to fall. When this symptom appears only upon syringing the ear, the drum membrane will usually exhibit a large perforation exposing the head of the stapes to the direct impact of the current.

Chronic suppuration need not necessarily cause constant discharge from the ear. The patient may be free from the symptom for weeks or even years. This intermittency depends upon the precise nature of the local changes within the middle ear and also upon certain associated conditions of the upper air tract. In children where the membrana tympani has been extensively destroyed as the result of one of the exanthemata, we frequently have the history of a discharge from the ear only when the patient has a cold in the head. In such a case, usually, the internal wall of the middle ear is exposed over a very large area, and the mucous membrane covering it participates in any vascular changes which may take place in the associated organs. Hence an acute rhinitis or an acute naso-pharyngitis, especially if the pharyngeal tonsil is hypertrophied, causes a similar hyperæmic condition of the mucous membrane of the middle ear. Add to this the exposure of the membrane by the loss of the membrana tympani, and it is easy to understand why the discharge recurs at such a time. The attack is really one of tubo tympanitis, but as the tympanum is freely open, the serous transudation appears in the canal. In other instances inquiry will fail to elicit any history of discharge, but the patient may state that at intervals small yellowish-brown crusts collect in the meatus and constitute a source of annoyance. Careful examination shows that these so-called crusts are masses of inspissated pus which collect in the deeper portions of the canal and constitute a source of discomfort only when they appear at the orifice of the meatus.

Certain symptoms referable to the external canal may also be present. The development of a fungus upon the walls of the meatus is not uncommon, as the parts are continually bathed in secretion. The symptoms may be so slight as to escape notice, or there may be an intense burning or stinging sensation in the ear, together with pruritus. Where proper attention is not paid to cleanliness, a circumscribed external otitis may result, producing the symptoms characteristic of this affection. Diffuse inflammation of the external meatus is rather uncommon unless the mastoid process is involved.

The development of facial paralysis was formerly supposed to be indicative of involvement of the mastoid. This is by no means true. The facial nerve in its passage through the tympanic cavity is ordinarily completely inclosed in a bony canal, and pressure symptoms are impossible unless this bony wall is wanting at some portion, either as an anomalous anatomical condition or as a result of necrosis. In either of these conditions the trunk of the nerve may be pressed upon and facial paralysis of the corresponding side result. Where the canal is imperfect the nerve itself may become inflamed and the integrity of the facial muscles be impaired without any inflammatory changes taking place in the bony wall. When cholesteatoma develops, the pressure upon the nerve trunk may produce this symptom when the bony wall has been incomplete originally or has been partially absorbed by pressure.

The occurrence of granulation tissue suggests the presence of necrotic bone, provided the ear has been kept thoroughly cleansed, and its recurrence after removal, with subsequent thorough cleansing, is pathognomonic of diseased bone. Where the parts have not been thoroughly freed from the discharge the action of the heat of the body, together with the moisture, induces exuberant granulations to spring up about the edges of the perforation in the drum membrane, and may often excite a similar process from the internal tympanic wall or from the various reduplications of mucous membrane within the middle ear, although the osseous structures may not be affected. These granulations, when they are due to hypernutrition of the soft tissues, yield very rapidly to chemical caustics if the parts are kept thoroughly cleansed, and a careful observation of their behavior under treatment enables us to recognize the involvement of the bony parts with absolute certainty. Where the secretion is very scanty, amounting to but a fraction of a minim daily, it may not escape from the meatus at all, but adhere to the walls of the canal and form a crust upon the posterior or superior wall of the meatus. Close to the membrana tympani it spreads downward and conceals it more or less completely. The presence of such a scale should always lead us to suspect a suppurative process within the tympanum, although the patient may deny positively that the ear has ever been the seat of a purulent discharge. In these cases there has usually been caries of the ossicular chain. Most frequently the incus has been the seat of the destructive process which may have occurred in early childhood, although it may not be discovered until adult life. The perforation is frequently small and situated high up in the membrana tympani in its flaccid portion. It is in these cases that we may have serious mastoid complications if the condition is allowed to go on unchecked; in fact, the mastoid inflammation may be the first symptom which causes the patient to direct his attention to the ear. More rarely the case is still more serious and intracranial infection takes place and progresses so insidiously that the patient is beyond all hope before the trouble is discovered.

The symptoms which characterize labyrinthine involvement are sudden dizziness, nausea, and profound deafness. A moderate involvement of the labyrinthine structures is common in cases where the disease has persisted for a long period. Notwithstanding this fact, the hearing may be but little impaired, the labyrinthine affection being confined to that part of the organ which is concerned in the appreciation in the highest notes of the scale—tones which are but little used in carrying on the ordinary vocations of life.

Diagnosis.—A. *Physical Examination.*—It is impossible to describe the manifold appearances which may be observed in chronic purulent otitis. For convenience we may divide them into six groups:

1. Destruction of the membrana tympani over a large area, with thickening of the mucous membrane over the internal tympanic wall and hypersecretion from the exposed surface (Fig. 106).

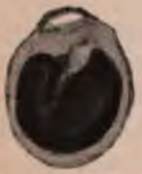


FIG. 106.—Chronic purulent otitis media. Extensive destruction of the membrana vibrans.

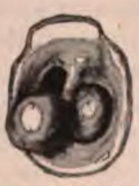


FIG. 107.—Chronic purulent otitis media. Exuberant granulation tissue developing within the tympanum.

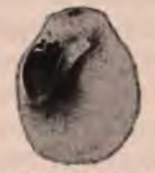


FIG. 108.—Chronic purulent otitis media. Membrana tympani adherent along inferior margin of perforation.

2. Extensive destruction of the membrana vibrans, with the development of granulation tissue over the internal wall of the middle ear (Fig. 107).

3. But slight destruction of the membrana vibrans, usually

in the posterior quadrant; adhesions between the margin of the perforation and the internal tympanic wall, except at the upper border, where a sinus leads directly into the vault of the tympanum. In these cases granulation tissue may be present, protruding from the orifice of the sinus, or the channel may be perfectly free. This appearance is indicative of caries within the middle ear (Fig. 108).

4. Membrana vibrans intact; perforation through the membrana flaccida, above the short process of the malleus. Here granulation tissue may or may not be present. The appearance is always indicative of diseased bone (Fig. 109).

5. Entire membrane swept away, except the cartilaginous ring and a small portion of Shrapnell's membrane which envelops the ossicula or their remnants, partial destruction of the chain, as a rule, having taken place. In these cases there is usually a sinus beneath the anterior or posterior ligament, sometimes in both situations (Fig. 110).

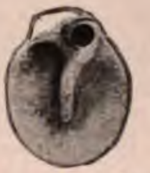


FIG. 109.—Perforation above the short process of the malleus.

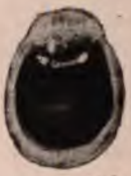


FIG. 110.—Chronic purulent otitis media. Ossicles displaced.

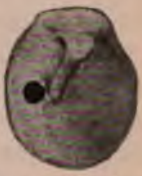


FIG. 111.—Chronic purulent otitis media. Small perforation behind the umbo.

6. A small perforation through the membrana vibrans, the drum membrane otherwise intact. This appearance is met with in childhood, and is indicative of infection of a simple catarrhal inflammation of the tympanic cavity, due usually to neglect (Fig. 111).

In inspecting any case, particular attention should be paid to an investigation of the entire periphery of the membrana tympani. Not only the membrana vibrans, but especially that part lying about the short process, should be carefully examined. This latter step should be taken, although a perforation may be present in the lower portion of the drum membrane, which seems to explain sufficiently the presence of the discharge. A coexistent loss of substance in Shrapnell's membrane may be found which will modify decidedly the prognosis in the case.

The free use of the probe is not difficult in these cases, since the middle ear is scarcely sensitive. We should determine whether the discharge really proceeds from an exposed surface or simply flows over this, originating in the upper part of the tympanic cavity. When this is the case, it will always be possible to insert a delicate probe under the posterior or anterior fold and carry it upward into the vault. The simplest means of doing this is to wind a pledget of cotton firmly upon a small cotton-holder, the cotton extending for some distance beyond the end of the instrument. If wound firmly, this cotton tip possesses considerable power of resistance, and causes less pain upon impact than does a metallic instrument. The cotton should be bent at a right angle, the angular portion being about one eighth of an inch in length. It is sufficiently firm to permit its introduction beneath the anterior or posterior fold of the membrana or into the small perforation in its lower portion. By manipulation it should be carried successively to the different parts of the middle ear, when, if exposed bone is encountered, the operator will recognize the fact by the cotton catching upon the rough surface. When this is not felt, it is well, upon removing the instrument, to examine the cotton carefully by means of a magnifying glass. Contact with exposed bone will pull out some of the strands, and this sign is as positive an evidence of caries as that afforded by the use of the probe in any other portion of the body.

Granulation tissue may develop to such an extent as to completely fill the meatus, in which case its recognition is a matter of no difficulty. In cases where it comes through a perforation in the membrana flaccida, it may be so closely applied to the periphery of the perforation as to render the line of demarcation almost indistinguishable. Here the mistake may be made of confounding the appearance with a bulging of the upper portion of the drum membrane, but careful manipulation with the probe will reveal the true nature of the condition. The granulation tissue pits easily on pressure, and the slight amount of mobility which it possesses points clearly to a pedunculated attachment.

The mucous membrane covering the internal tympanic wall may resemble so closely the appearance of a bulged and reddened drum membrane as to mislead us, unless we bear in mind that where the membrana tympani is present we are able to follow any one wall of the canal continuously across the fundus until it merges into the opposite wall, the outline being unbroken. If we are dealing with a case in which the internal wall of the middle ear is exposed, we shall find a solution of continuity at the very periphery, between the margin of the canal, which stops here abruptly, and the reddened wall of the middle ear, which lies at a lower level. The recollection of this simple fact will render a mistake in diagnosis rare.

The recognition of the ossicula is frequently a matter of no small difficulty. The short process of the malleus usually preserves its normal position more nearly than any of the other landmarks, and should be first sought. When this is recognized, if the shaft is present, we can usually make it out. If it does not lie in its normal position, or if it is found to be slightly displaced backward and inward, the head of the patient should be tilted far over toward the opposite side and the region between the short process and the internal tympanic wall carefully inspected. Necrosis of the tip of the malleus is not uncommon, and then the manubrium is usually slender, and drawn upward and inward by fibrous bands and completely hidden from view by the prominent short process and the hypertrophied posterior and anterior folds.

It is of special importance to inspect the upper and posterior quadrant of the field for an explanation of the degree of functional impairment. The stapes may frequently be seen in this region lying close to the margin of the tympanic ring, and partially concealed by it. If the head of the patient is inclined well to the opposite side, and at the same time tilted a little backward, we are able to look beneath the obstructing margin, and can usually recognize the head of the ossicle. Where extensive destruction has taken place the long process of the incus is often wanting; if present, it may occupy its normal position, the incudo-stapedial articulation being clearly visible. When the lower portion alone is destroyed the remnant is usually displaced toward the malleus, lying between the manubrium mallei and the head of the stapes.

Too much stress can not be laid upon the importance of first cleansing the ear most thoroughly by means of the cotton pledget and employing the probe, lightly touching each prominent point before attempting to interpret the condition of the parts. In an ear which has been properly cleansed an exact diagnosis is not difficult if the normal anatomical position of the parts is borne in mind. Where any secretion is present an exact diagnosis is impossible, and a correct interpretation is the result more of good luck than of skill. In addition to the ossicula, certain landmarks may be recognized on the internal tympanic wall. In the anterior quadrant, either partly below or above the median plane, there is a hemispherical depression just at the margin of the ring, which marks the tympanic orifice of the Eustachian tube. In the posterior quadrant the promontory terminates close to the tympanic ring. This break in the outline marks the niche of the round window lying below the head of the stapes, and in a plane almost at right angles to the plane of the oval window. Occasionally the niche of the fenestra rotunda is exceedingly well marked, and when associated with a contraction of the meatus at its inner end the promontory may be mistaken for an exostosis.

Inflation by means of the catheter gives auscultatory sounds, which vary according as the middle ear is shut off from the Eustachian tube by adhesions, or where the tympanic orifice is patent. When the inner extremity of the tube has been occluded by an hypertrophic process, no sound of air entering the tympanum is perceived, each compression of the bulb being heard as a faint, distinct, percussion sound. It is distinguished from the sound heard when the tube is occluded at the isthmus from the more immediate proximity to the ear of the observer, and also by the absence of mucous pharyngeal rhonchi, which usually accompany this latter condition. With a patent tube the sound varies from a full blowing sound where the perforation is large to a sharp whistling note when the air passes through a small opening. Frequently perforations in the upper part of the drum membrane do not modify the normal auscultatory signs because the tympanic vault is entirely shut off from the atrium by adhesions, and inflation produces the characteristic impact sound as the air impinges upon the drum membrane.

Involvement of the mastoid process is characterized by pain and tenderness over the mastoid region externally, and usually by a diminution in the amount of discharge. Within the canal we find the parts tender along the superior and posterior walls close to the tympanic ring. Very soon after the mastoid has been attacked the soft tissues in this region sag into the lumen of the meatus, narrowing the fundus, and in severe cases may lie in contact with the opposite wall. This prolapse of the supero-posterior wall of the bony canal is pathognomonic of an inflammatory process within the mastoid, and we need no other indication before resorting to immediate operative measures. The temperature is in nowise indicative of extension in this direction; quite frequently the temperature remains normal, although the pneumatic spaces in communication with the tympanic cavity have become involved.

B. *Functional Examination.*—The hearing for sharp sounds is reduced, and conversational voice and whispered speech may be heard as well or better than either the watch or acoumeter. The lower tone limit is elevated; the upper tone limit is frequently normal, especially where the parts are moist, and where the process has not existed for many years. In some cases we find that high notes are better perceived than under normal conditions. Where the ear has been the seat of a purulent inflammation for a long period of years, the upper tone limit is often considerably lowered. This indicates labyrinthine involvement, which is usually not progressive. Bone conduction is increased in most cases. Where one side alone is affected, the tuning fork on the vertex is heard better by the affected ear; the normal ratio between bone and air conduction is reversed for the lower notes of the scale, frequently for all notes below the c″—512 V. D. The galvanic irritability is usually increased while the middle-ear process is active; when this is quiescent such a reaction to the galvanic current would be indicative of labyrinthine inflammation or congestion.

Prognosis.—We consider under prognosis, first, the degree of functional impairment which the patient will suffer; second, the continuance or cessation of the discharge; third, the danger to life.

In considering the probable degree of functional impairment, we must remember in general that a suppurative inflammation endangers the hearing much less than does a nonsuppurative process. The amount of destruction that has resulted furnishes us few data upon which to base an opinion. The condition of the parts in the upper and posterior quadrant, however, may aid us in estimating the probable degree of impairment which will result; if the stapes is exposed and is movable upon manipulation and the niche of the round window is unobstructed, deterioration of the hearing should not take place beyond that originally present when the patient first comes under observation; on the contrary we should expect it to improve considerably from the reduction of the inflammatory process and from surgical measures directed toward adhesions which may be present. When the stapes can not be seen but adhesions exist which, from their location, might fix it firmly, the chances of improvement are still good. With a normally movable stapes and where the round window is not occluded, it is not probable that any measure directed toward the middle ear will greatly increase the power of audition. In interpreting these appearances we naturally correlate the results of the functional and physical examinations. With labyrinthine involvement we may hope for improvement from internal medication, although a guarded opinion should be given as to the degree which will be attained.

Concerning the cessation of discharge, the chief factor is the presence or absence of diseased bone and the extent to which the osseous tissues have been invaded. If we find that the bony ring has been involved and the disease is of long duration, it is quite probable that softening has occurred in regions inaccessible to instruments introduced through the meatus. If the ossicula alone are the seat of the necrotic process or if we believe that the walls of the middle ear are but slightly involved, our prognosis is then fairly good regarding the ultimate cessation of the otorrhœa. When no dead bone is present we should be able to promise absolutely that the discharge will cease under proper treatment. We can also promise that the danger of subsequent mastoid involvement will be removed. But in any given instance where the osseous structures have been invaded, to promise absolutely that the discharge will cease, is certainly unwise.

Concerning the danger to life, we need only to remember that insurance companies constantly reject applicants suffering from a chronic otorrhœa, to appreciate how grave a menace to life the condition is. Where the mastoid is not involved and an examination reveals no evidence of intracranial involvement at the time of the investigation, we can promise that by properly conducted treatment the process will not endanger the life of the patient. With mastoid involvement there is always a certain element of danger dependent upon the degree;

when intracranial changes have already taken place the prognosis is very grave. The variations in conditions which influence our opinion when the mastoid is involved will be fully discussed in a chapter on this subject. Subjective noises, as a rule, are not distressing in the disease under discussion; but when present, it is difficult to secure a complete subsidence of tinnitus unless it results from an acute exacerbation of the chronic disease.

Treatment.—In the treatment of these cases we endeavor to accomplish two results: first, to stop the discharge; second, to improve the hearing and relieve the subjective disturbances if any are present.

In order to accomplish the first purpose it is necessary to see that the ear is kept thoroughly cleansed in order that the combined influence of heat and moisture may be removed. If the patient is to be treated at the hands of the surgeon every day and the discharge is only moderate in quantity, this may be removed in whatever way seems advisable, either with the cotton pledget or by irrigation with the syringe. If the treatment is to be conducted by the patient, irrigation affords the only safe means by which this object can be effected. The frequency with which irrigation should be repeated depends on the quantity of discharge, which must not be allowed to accumulate in the canal. In children, where the process is very active, or in cases that have been neglected for a long time, it is well to begin by having the ear syringed every two hours. The attendant or the patient himself must be instructed carefully in the manner of performing this apparently simple operation. In the large majority of instances if this is not done the pus will not be thoroughly removed from the canal by the procedure; consequently particular attention is directed to this point. In the adult patient the ear is to be drawn upward and backward by grasping the auricle between the index and middle fingers of the left hand, thus straightening the auditory meatus. The syringe should have a blunt nozzle, rendering it impossible for it to be carried in the meatus far enough to impinge upon the membrana tympani. After the irregularities in the canal have been overcome in the manner described, the syringe should be introduced into the meatus as far as possible and directed inward and slightly downward and forward toward the tip of the nose. In young children the curves of the canal are best obliterated by pull-ing the auricle outward and downward, as shown in Fig. 87. If the syringe is pointed upward and inward the fluid will cleanse the deeper parts more thoroughly than if the directions just given for the use of the syringe in adult patients are followed. The irrigating fluid is injected with a moderate amount of force, and the return current holding the pus in suspension is allowed to flow into any convenient receptacle which the attendant, or even the patient himself, holds under the ear close to the side of the face. The temperature of the fluid is a matter of considerable importance; both hot and cold solutions are painful when introduced into the meatus, and the sensations of the patient should guide us in choosing the proper temperature. The amount to be used at each irrigation should not be less than half a pint, and it is frequently advisable to use more.

Concerning the choice of a fluid for this purpose, we may use either a bichloride-of-mercury solution (1 to 5,000 or 1 to 8,000) or water which has been boiled and allowed to cool to a lukewarm temperature, or a saturated solution of boric acid, or a two-per-cent solution of carbolic acid, or any other convenient solution. In cases which have formerly been under treatment, and the patients know by experience the effect which fluids have upon the ear, the surgeon may be told occasionally that the result of the so-called "wet treatment" has been to increase the discharge. Many of these patients are able to wipe out the ears very successfully with a small pledget of cotton twisted about a bit of wood or upon a metallic cotton holder. We should never disregard these statements on the part of the patient without some good reason, and it is well not to insist upon the use of fluids if there is evidence that these have formerly increased the trouble.

The removal of the discharge causes the swelling of the tissues within the middle ear to diminish, and with the disappearance of the congestion and œdema the discharge will diminish in quantity and the parts resume their normal appearance.

We should now carefully investigate as to the cause of the flow. If we find the mucous membrane within the middle ear exposed over a large area, as is the case when considerable of the membrana tympani has been destroyed, and the exposed mucous membrane is swollen, hypertrophied, turgescent, and moist, the indication is to cause an absorption of the hypertrophied tissue and restore the local circulation to a normal condition. Certain conditions of the upper air passages may tend to keep up a state of chronic congestion within the middle ear, and investigation of the nose and naso-pharynx should never be omitted.

Where adenoid vegetations are found, it is well to begin our treatment by their removal. Enlarged faucial tonsils do not as frequently cause trouble, but if the organs are excessively hypertrophied, they should be removed. Hypertrophy of the turbinated bodies or other marked obstructive conditions in the nasal cavity also demand treatment, in order that there shall be no barrier to the free venous flow from the middle ear.

Applications should also be made to the exposed lining membrane of the tympanum. For this purpose solutions of nitrate of silver may be employed, beginning with a two-per-cent solution, and rapidly increasing the strength, according to indications, up to two hundred and forty grains to the ounce, if necessary. The copper salts, if employed, should be used in less saturated solutions—ordinarily of a strength of not more than ten grains to the ounce. The practice of allowing these patients to instil astringent solutions into the ear is not advisable, particularly aqueous solutions of sulphate of zinc with a small amount of glycerin added, to retain the astringent for a longer time in contact with the mucous membrane. A solution of this sort affords an excellent soil for the development of the various vegetable molds, and this occurrence often follows its continued use. If the patient is able to visit the surgeon only occasionally the preparation which is best adapted for his use at home is an alcoholic solution of boric acid in the proportion of twenty grains to the ounce. Where the internal wall of the tympanum is exposed over a large area, this solution produces particularly good results, the alcohol acting as a local stimulant to the parts, while, in combination with boric acid, it possesses sufficient antiseptic properties to keep the parts free from the development of any of the low vegetable organisms. It also exerts a decided astringent action, preventing the formation of granulation tissue.

The use of powders which the patient is to blow into the ear can not be too strongly condemned. Under no condition should the patient be supplied with any remedy in this form.

Even in cases where the perforation is very large, it is possible for a preparation of this character to dry into a firm crust after absorbing the discharge, and this crust may become so closely attached as to constitute a barrier to the free outflow of secretion, in case this becomes suddenly augmented in quantity at any time. Pus retention under these circumstances does not differ from retention of purulent material from any other cause, and in a considerable number of cases death has resulted from the incautious use of powders. In the hands of the surgeon some of the astringent or stimulating powders are of great value. We sometimes find that after the discharge has been greatly reduced a small amount of moisture still persists, and the progress of the case stops at this point. The use of fluids in these cases seems to tend rather to keep up the discharge. The insufflation of a minute quantity of boric acid, oxide of zinc, iodoform, or a mixture of equal parts of alum and boric acid is frequently followed by a complete cessation of secretion, the ear remaining perfectly dry. The fact must be emphasized that but a minute quantity of any such preparation is to be used, just sufficient to cover the mucous membrane. In the case of boric acid a little may also be dusted upon the walls of the meatus, but the practice, sometimes recommended, of filling the canal with the powder should never be adopted. In no case should powder be used even by the surgeon if an interval of more than forty-eight hours is to elapse before the next visit, and the patient should be directed immediately to syringe the ear thoroughly if at any time there is pain, giddiness or a considerable increase in the discharge. With these precautions I thoroughly approve of the use of powders, but under no other circumstances.

In other cases we find that our efforts are unsuccessful, although most carefully conducted. This should always cause the suspicion of diseased bone in some portion of the tympanic cavity. Naturally this has already been sought in the first examination, but if treatment has been conscientiously carried out in the manner described for a period of three to four weeks without reducing the quantity of the discharge considerably we may assume safely that diseased bone is the cause of the trouble. This applies to cases where no granulation tissue is present; in many instances we find this additional symptom. Where, upon primary examination, exuberant granulations are present to such a degree as to fill the fundus of the canal, or even if confined to a limited area, these should be dealt with before methods other than simple cleansing are instituted. If the granulations are of small size they may be destroyed *in situ* by the chemical or potential cautery. The chemical agents employed for this purpose are chromic acid or silver nitrate, either of which may be fused upon the end of a metal probe and lightly applied to the granulation tissue after thoroughly drying the area to be touched. Any excess of the agent must be wiped away by means of a dry pledget of cotton to prevent it from spreading over the entire lining membrane of the middle ear. Where the tissue is soft and but little elevated above the general surface of the mucous membrane, a saturated solution of persulphate of iron may be employed. Chromic acid is more suitable for the destruction of large granulations than any other chemical agent, since severe inflammatory reaction very rarely follows its use. The manipulation of the actual cautery is difficult, and is rarely more efficient than the means above mentioned. Where the granulations are of larger size they should be removed by means of the cold wire snare (Fig. 112), the loop being carried upward to the base and made to surround it, when by drawing the wire into the tube of the snare the growth is cut off close to its attachment. I much prefer this method to evulsing the growth after it has been surrounded by the loop. A practice which I often employ in these cases is removal of the tissue by means of the sharp curette (Fig. 113). Instruments of various sizes are necessary in order to perform the operation effectively in this manner. The curette is carried into the canal, passed

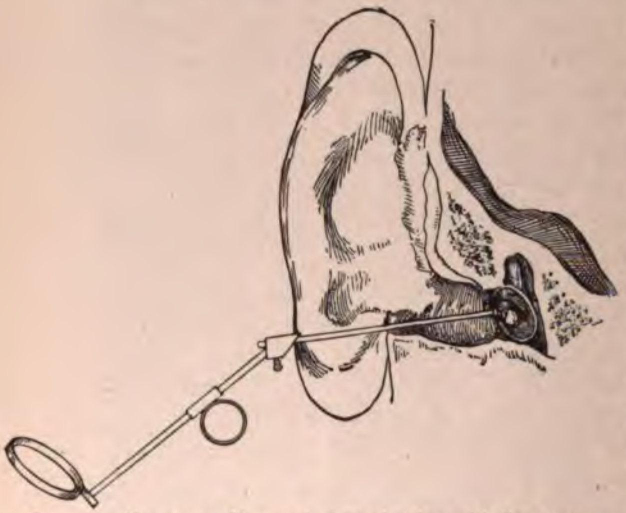


FIG. 112.—Removal of aural polyp with the snare.

below the growth, and then raised so that the ring of the instrument will encircle it; by moving the curette delicately it can be carried upward along the pedicle to its point of attachment; then, by pressing the instrument firmly against the wall of the canal, and at the same time drawing it outward, the mass is removed.

This procedure is not painful if care is taken not to touch the walls of the meatus during the introduction of the instrument. The advantage of this method lies in the thorough extirpation of the mass, which is usually severed close to its base. After removal, a pledget of cotton, saturated in a 1 to 1,000 solution of adrenalin chloride, is inserted into the canal and crowded rather firmly into the fundus to check whatever hæmorrhage may occur.

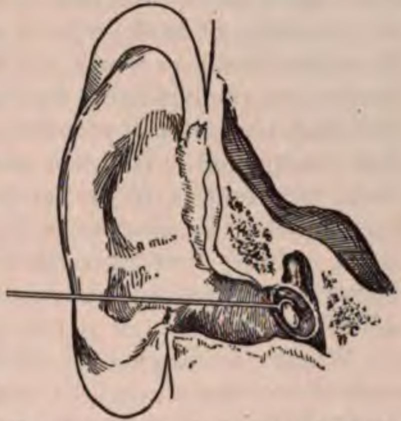


FIG. 113.—Removal of aural polyp with the sharp curette.

After a few moments this tampon is removed and the parts thoroughly cleansed by the cotton pledget, after which the stump is cauterized. If, after a thorough removal in this manner and careful cleansing of the ear for a period of several days, the tissue reappears, dead bone is certainly present. No other condition but the presence of a foreign body can cause this phenomenon, and measures should at once be instituted to remove the offending substance.

Owing to the possibility of infection of the intracranial structures through the raw surface left by the removal of granulation tissue, even this simple procedure should never be performed unless the patient can be kept under close observation for several days after the operation.

It often happens, in an ear which has been the seat of purulent process since early childhood, that the discharge ceases and the ear remains practically dry, but occasionally a small amount of offensive discharge appears at the meatus. It will frequently be found that this symptom is due to the presence of an aspergillus which has found lodgment and subsequently developed in the meatus or upon the internal tympanic wall.

Owing to the presence of a slight amount of moisture it has developed in this situation, and afterward its presence increases the discharge, and thus facilitates its own growth. This fact is mentioned since its occurrence may mislead us as to the result obtained by previous treatment in any given case. In several cases in which the ossicles had been removed for caries, and the discharge had ceased completely, the patients returned after several months complaining that the discharge had reappeared. This was found to be due to the development of a fungus in the canal. Thorough cleansing and an application of a solution of the bichloride of mercury, in diluted alcohol in the proportion of 1 to 2000, destroys such growths, and restores the parts to their previously quiescent condition.

Where the discharge depends upon the lack of proper care in treating a previous acute catarrhal inflammation, we find that the perforation in the membrana tympani is of but small size, and that the purulent discharge is due to an infection of the normal mucous secretion of the middle ear. After infection the fluid products are but imperfectly evacuated, owing to the narrowness of the opening. The first indication here is to secure free drainage by enlarging the opening with a blunt knife. If the fluid is viscid, it is frequently wise to make two diverging incisions, inclosing a V-shaped flap, to permit the complete evacuation of the contents of the cavity upon inflation of the middle ear. After thorough cleansing—first by inflation, and subsequently by irrigation of the tympanic cavity by means of the middle-ear syringe (shown in Fig. 99), and thoroughly disinfecting the meatus—these cases may recover with no further treatment. If this does not occur, the lining of the tympanic cavity is to be stimulated by the injection of a mild astringent fluid, introduced by means of the tympanic syringe. The delicate delivery tube of the instrument is carried through the perforation and a sufficient quantity injected to fill the tympanum completely. We usually recognize the fact that a sufficient amount has been injected by the passage of the fluid through the Eustachian tube into the pharynx. We should never begin with a solution of nitrate of silver stronger than five grains to the ounce of water, subsequently increasing the strength as we find the parts tolerant to the drug. Only solutions sterilized by heat should be used in this manner, and the instruments employed must have been subjected to a similar process. Where the discharge still continues in spite of this treatment, and no condition is present in the nose or naso-pharynx which would tend to aggravate it, good results may often be obtained by applying a paper dressing to the part after the middle ear has been thoroughly cleansed and the mucous membrane subjected to the action of appropriate drugs. This paper dressing was first used by Blake, and consists of a small bit of thin sized paper of appropriate shape, which is first moistened in a solution of bichloride of mercury, 1 to 1,000, and conveyed into the middle ear by the forceps or upon the tip of the cotton holder. The surface of this disk of paper is applied to the drum membrane, and by manipulation so placed as to occlude the opening in it. When in position, its edges are firmly but delicately pressed upon, to secure close contact with the drum membrane at every point. The efficiency with which this has been done can be demonstrated by gently inflating the ear, when no perforation sound will be heard if the operation has been satisfactorily performed. A little boric acid is now lightly dusted over the disk and the membrana tympani. This dressing will remain in place for a period varying from four days to two weeks, at the end of which time it will probably have been carried toward the periphery of the membrane, exposing the margin of the perforation. Another dressing should now be applied in the same manner as before, overlapping the first disk, so that, as the exogenous growth of the membrane carries the first outward, the opening will be gradually occluded by the second dressing. The stimulation which the presence of this foreign body produces is frequently sufficient to effect a complete closure of the opening in the membrana tympani, while its protective action induces retrograde changes in the congested lining of the middle ear after securing free drainage by enlarging the opening. Where a sinus leading into the tympanic vault is present immediately beneath either the anterior or posterior fold, it is probable that the osseous structures have been involved by the inflammatory process. If we do not detect the presence of dead bone upon examination, the treatment detailed in the preceding pages may be followed for a few weeks; but, in addition, the vault of the cavity should be irrigated by means of the tympanic syringe, the delivery tube being bent upward at its extremity, so as to admit of insertion into the sinus and injection of the fluid into the upper spaces (Fig. 114). Naturally such manipulation can only be carried on by the surgeon himself. The irrigation should be repeated at first daily, and subsequently less frequently, as the discharge diminishes in amount. In cases where bony necrosis has taken place the diseased bone may have been thrown off spontaneously, either disintegrating and discharging in the form of pus, or it may have come away as a sequestrum at some former time.

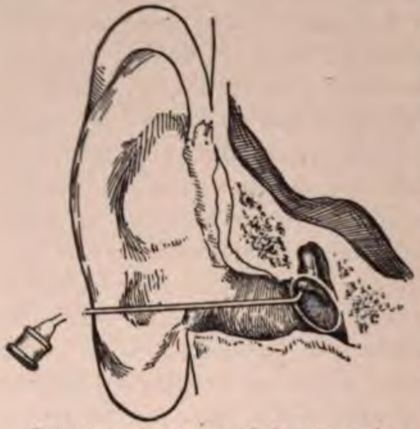


FIG. 114.—Irrigation of the tympanic vault.

Here the persistence of discharge depends upon the retention of the secretion in the reduplications of the mucous membranes in the vault of the cavity. It is for this reason we are warranted in attempting at first to check the discharge by mild measures. Peroxide of hydrogen, either dilute or of full strength, has been highly recommended by some observers for the irrigation of this region; aside from the fact that the antiseptic action of this drug is visible, I see no reason why it possesses any advantages over other solutions which are known to destroy pathogenic bacteria. Certainly its entrance into the mastoid cells is undesirable because of the pressure exerted by the gas evolved during its action.

Failing in any of these simpler measures, we may feel certain that the discharge is due to the presence of diseased bone, and when we are confident of this fact the only rational procedure is to remove it. The extent to which the bony structures are involved influences the prognosis materially; if confined to the ossicles the discharge will certainly cease upon ossiculectomy and thorough curetting of the tympanic walls. If the process is so extensive as to involve the osseous walls in regions inaccessible to instruments introduced through the meatus, the removal of the ossicles may still be indicated for the purpose of securing free drainage of the intratympanic spaces, although the discharge may not entirely cease. When there is sagging of the superior wall of the canal, a history of previous mastoid symptoms or mastoid tenderness, and a purulent discharge so profuse that it must originate in a cavity of greater size than the middle ear, the ideal procedure is an external operation, completely exposing the pneumatic spaces of the mastoid, together with the walls of the tympanum. Theoretically, such an operation should always result in a complete cure. Practically, the results obtained are frequently so satisfactory after the operation for removal of the ossicles and curetting the adjacent tympanic walls through the meatus that this operation is frequently chosen by the surgeon, and often with most satisfactory results. Unfortunately, even after a complete radical operation, some little discharge may remain. In doubtful cases the surgeon is justified in recommending the simpler operation first, giving the patient to understand that if this procedure is not followed by complete cure, and if disagreeable symptoms still continue, the more extensive operation will be necessary.

Operative procedures can not be too strongly urged in all cases where the presence of diseased bone is made out either by tactile examination or is quite as certainly indicated by the persistence of the discharge in spite of appropriate treatment.

Regarding the efficacy of the operation of excision of the ossicles and curettement of the tympanum, Ludewig * reported forty-two cures in seventy-five cases operated upon. Grunert † cited thirteen cures in twenty-eight operations. The author ‡ reported nearly two years ago fifteen cures in twenty-nine cases operated upon, while in nine the discharge was greatly reduced in quantity. The author's later operations have given about the same results. In a total of ninety-two cases operated upon, fifty-three have been cured, twenty-five improved, and two unimproved. In the remaining twelve cases the result is unknown. Of the cases last mentioned two were seen but once after the operation; the others were improving when last seen.

So far we have considered the effect of treatment upon the discharge alone. Concerning the function of the organ, it may be said that, in cases of extensive destruction of the membrana

---

* Arch. für Ohrenheilk., vol. xxx, p. 263.

† Ibid., vol. xxxiii, p. 207.

‡ Supplement to Reference Handbook of Medical Sciences, New York, 1893, p. 244.

tympani and the formation of adhesions between the ossicula, the power of audition may diminish slightly, owing to the increased tension, after the parts become perfectly dry. This fact does not render the necessity or advisability of stopping the discharge less imperative, since any resulting impairment of function can be corrected by division of the adhesions at a subsequent period, while the continued secretion of pus is a constant menace to life. Following surgical procedures, the function of the organ is usually improved where the hearing is considerably impaired before the operation. Where the hearing is but slightly impaired we need not fear that it will be reduced by the operative measures proposed. Ludewig * reports a slight impairment of the hearing as a result of the operation in six cases out of seventy-five operated upon. In my own cases but one instance of this kind has occurred in fifty operations. Impairment of the function more frequently follows the cessation of the discharge from treatment with astringents or caustics than from the method now under consideration. We assume here that the impairment in function is due principally to the intratympanic lesion and not to any labyrinthine involvement. Extensive involvement of the labyrinth would contraindicate an operation for the improvement of hearing alone, but should scarcely stand in the way of the procedure for the relief of the discharge. The relief of subjective noises can very rarely be promised from any form of treatment, although where the mucous membrane is very much congested we should hope to abate their intensity as we reduce the turgescence. It is never safe to promise relief from this symptom by operative measures. On the other hand, these last-named procedures seldom or never produce subjective noises.

The changes which take place in the tympanic mucous membrane after the removal of the ossicles and of the remnant of the membrana tympani vary considerably in different cases. The most favorable change is one in which the mucous membrane gradually undergoes dermoid transformation. If this occurs, the membrane no longer secretes, and the patient is not liable to recurrent attacks of discharge from the ear whenever the upper air tract becomes acutely inflamed. In children this transformation takes

---

* Arch. für Ohrenheilk., vol. xxx, p. 263.

place only after a long period, but in adults we may hope for it in from eight to ten months after the operation. Certain steps at the time of the operation may hasten this transformation. Thus, if a small segment of the membrana tympani is allowed to remain at the lower part, and the mucous membrane over the promontory immediately opposite this segment is denuded by means of the curette, this small flap will apply itself to the denuded surface and rapidly become attached. The superficial epithelium spreads over the wall of the middle ear, transforming it into a nonsecreting surface. Where the mucous membrane remains intact, even although our procedure may have stopped the discharge permanently, we should remember that any severe congestion or inflammation of the upper air tract, such as a severe cold in the head, may produce a temporary otorrhœa; this will usually subside spontaneously when the exciting cause has disappeared. In order that this may happen, the canal must be kept free from any infection while the discharge lasts. This end may be attained by cleansing the canal with the syringe twice daily. The solution to be employed should be of a mild antiseptic character. A solution of bichloride of mercury (1 to 8,000) answers the purpose admirably. After irrigation the patient should instil a few drops of an alcoholic solution of boric acid (gr. xx to ℥j) or of bichloride of mercury (1 to 3,000) into the ear.

If the discharge is but slight and the patient is seen daily it may be sufficient to dry the parts thoroughly with cotton and then apply one of the alcoholic solutions above mentioned to the walls of the meatus and middle ear with the cotton applicator. If these measures are carefully carried out the discharge will cease in a few days.

A condition which we may sometimes be called upon to combat by operative interference is where this dermoid transformation takes place spontaneously in cases which have not been subjected to treatment. Where a small perforation is present in the upper portion of the drum membrane the epithelium of its outer surface occasionally grows into the tympanic cavity, where it proliferates, lining the entire vault with epidermis. Owing to the increased vascularity of the part, this new lining membrane becomes the seat of a desquamative inflammation, superficial cells being produced and thrown off more rapidly than under normal conditions. The cavity becomes filled with desquamated epithelial cells, and certain changes occur as the result of pressure from this slowly increasing epithelial mass. The bony walls of the cavity are absorbed, and at the same time undergo consolidation as the result of chronic osteitis. An acute inflammation in an organ thus affected causes a sudden augmentation in the volume of this epithelial mass, and increases the pressure upon the surrounding walls. Sometimes the process is so insidious that the patient may not be cognizant of morbid changes in the ear until these symptoms, due to the sudden change, supervene, and the surgeon may first be consulted when operative measures alone will relieve the case. The problem which we have to solve in such an event is whether we shall relieve the symptoms by an operation through the canal, or whether it is necessary to open the mastoid. Experience shows that the changes may be confined to the vault of the tympanum. In recent cases, and where no marked mastoid symptoms exist, such as external tenderness, pronounced and extensive sinking of the posterior wall of the canal, and spontaneous pain over the mastoid, I am inclined to prefer clearing out the vault of the tympanum through the canal as a primary procedure. Frequently this is sufficient, and entire relief to the pressure symptoms follows, while at the same time the purulent condition is permanently arrested. When the process has invaded the mastoid, any operative procedure must not only remove the accumulation within the cells, but must also place these pneumatic spaces in communication with the meatus, in order that subsequent trouble may be avoided. From the nature of the pathological condition it may be practically impossible to extirpate every vestige of the lining membrane which has undergone dermoid transformation, and a recurrence may take place. It is our duty to establish a condition which will enable any subsequent accumulation to be removed without a severe operation. To effect this the mastoid is opened in the usual way, and the cell structure obliterated, after which the dividing wall between the artificial opening and the meatus is taken away, throwing the mastoid cells and external canal into one cavity. The external auditory meatus is then enlarged by a plastic operation, which will be more fully described under *The Radical Operation*. (See page 546.)

Any subsequent accumulation, due to epithelial proliferation, can then be removed directly through the external auditory canal.

This procedure, so hastily outlined, is applicable not only to cases of this desquamative inflammatory process, known as cholesteatoma, but also to all cases of chronic middle-ear suppuration, in which the bony involvement is so extensive as to preclude the possibility of removal of all diseased bone through the external auditory canal. The operation is known as the Radical operation, and is sometimes called the Stacke-Schwartze operation, the technique of which is described on page 546. The results obtained from this operation in chronic otorrhœa are exceedingly satisfactory. Out of 270 cases operated on by the author 166 were cured, in thirty-three there was a slight discharge after the operation, in eight a moderate discharge after the operation, in eight the discharge continued profuse after operation, in thirty-six cases the result was unknown, and twelve cases were still under treatment. There were seven deaths: two from pneumonia, two from meningitis, one from cerebral abscess, and two from cerebellar abscess. In none of the cases could death be attributed to the operation.

Of thirty-six cases recorded as "unknown," it is probable, from the fact that these did not report that the result was satisfactory.

Regarding the results upon the hearing, out of 111 cases in which the hearing was tested before and after operation, in ninety-nine the hearing was good after operation, in nine it was fair, and in only three cases was the hearing worse after operation than before.*

We have limited ourselves to local measures in considering the treatment. In patients of a lymphatic habit, particularly in children, much benefit will be gained by the internal administration of iodide of iron in full doses. Where evidences of malnutrition exist as the result of some hereditary diathesis, the exhibition of cod-liver oil and of the hypophosphites will be found beneficial. In the adult attention should be given to regulating the habits of life so as to diminish the tendency to congestion in the upper air tract as much as possible. The use of alcohol, and in certain cases of tobacco, is particularly to be interdicted, although the influence of the latter is comparatively slight.

---

* The above statistics appeared in the fourth edition of this work published in 1909. Since that time 536 cases have been subjected to this operation, and the results have been even more satisfactory than those given above. This is particularly true as far as improvement in the function of the organ is concerned.

CHAPTER XXIII.

OTITIS MEDIA PURULENTA RESIDUA.

By this term we designate that class of cases in which a former purulent inflammation has resulted in a permanent destruction of certain of the tympanic structures. Either spontaneously or as the result of treatment, the discharge has ceased, and we are called upon to relieve symptoms due either to the adhesions which have developed within the tympanum or to certain changes which have resulted from the purulent inflammation. For convenience we divide these cases into two classes:

1. Where the symptoms are acute or subacute.
2. Where the symptoms are of a chronic character.

1. Acute Cases.

Ætiology.—The underlying cause in these cases is evident from the title applied. As an exciting cause we may have any of those operative in the production of the various varieties of acute inflammation, but we usually find an acute inflammation of the upper air tract, either a simple coryza, an acute naso-pharyngitis, or an influenza of the epidemic character. Among other exciting causes we must bear in mind those which operate through the external meatus, such as the insertion of any device into the canal for cleansing the ear, blows upon the auricle, and the development within the tympanum of some of the vegetable molds.

Pathology.—The changes which take place vary widely according to the condition in which the previous inflammatory process has left the parts. Cases in which the membrana tympani has been almost completely destroyed, exposing a large area of the inner wall of the middle ear, present generally a simple venous hyperæmia of this membrane, resulting in œdema, and subsequently in serous transudation. The condition found here is similar to that described under acute catarrhal otitis media, or tubo-tympanic congestion occurring in an organ in which the membrana tympani is intact. In the cases under consideration the serous transudation, which results from the inflammatory process, appears in the external auditory meatus as a discharge, for the reason simply that the opening in the drum membrane allows it to escape from the tympanic cavity. Where the membrana tympani is intact the same transudation collects within the middle ear. It is a matter of some importance to remember this, as such a discharge does not become purulent unless infected from without. If the external meatus is kept in a thoroughly aseptic condition, the disease is self-limited and the discharge ceases spontaneously at the end of a few days. On the other hand, if infection occur, a chronic purulent otitis may result. The remaining portion of the membrana tympani is affected, becoming hyperæmic, desquamating if the process is pronounced, and increasing in thickness. Where the upper portion of the drum membrane remains, and the intratympanic folds has become much thickened by the development of new connective tissue, these lamellæ increase in volume, and may completely fill the vault. If this portion of the cavity is completely shut off from the atrium the subsequent transudation causes a bulging of the membrana flaccida, which may protrude into the canal so as to resemble closely a mass of granulation tissue. From the changes which have taken place it is usually so dense that the fluid inclosed can not escape by spontaneous rupture. The case then presents the characteristics of a primary acute purulent inflammation of the middle ear, with the exception that the osseous walls become involved more quickly than when the affection is primary. Destruction either of some part of the ossicular chain or of the surrounding tympanic walls results, and with a subsidence of the acute symptoms a chronic purulent otitis remains. When cholesteatomatous changes have taken place the involvement either of the mastoid cells or of the cranial cavity itself is exceedingly prone to occur.

Symptomatology.—In the cases in which the membrana tympani is destroyed over a large area, the symptoms consist of a slight impairment of the hearing, occasionally with the development of subjective noises. The prominent feature, however, is the appearance of a discharge from the ear.

This class of cases occurs most frequently in children of from eight to twelve years of age, in whom the chronic purulent otitis has followed one of the exanthemata in early life. Pain is not a prominent symptom as a rule, and were it not for the appearance of the discharge the attack would probably pass unnoticed. Occasionally we may have developed in the external canal an area of circumscribed inflammation due to local infection; when this occurs there is intense pain. In the cases in which the upper part of the cavity is affected the pain is severe, prostration well marked, the temperature is elevated from one to four degrees, and there may be no discharge, or, if present, it is usually scanty. The pain may be localized in the ear or may spread to the entire temporal region.

The occurrence of facial paralysis very early in the attack is not infrequent. The function of the organ may be but slightly impaired, owing to the location of the affected area.

Diagnosis.—The result of functional examination depends so much upon the previous condition that it need not be considered, acute symptoms alone demanding attention.

Physical Examination.—Upon inspection, where we find that the destruction of the drum membrane has been extensive, the exposed lining of the tympanum is red, velvety in appearance, and coated either with a colorless watery discharge, or, at a later period this is opaque in character. The remnant of the drum membrane is thickened, turgescent, and œdematous. When examined before the process is far advanced, it may present a dead-white appearance, owing to a necrosis of the superficial layer of its epithelium. Removal of this epithelial covering reveals a turgidity of the underlying parts. Where the upper segment of the cavity is involved, the remnant of the drum membrane is intensely congested, thickened, and, together with the adjacent canal wall, bulges into the lumen of the passage, narrowing the fundus to so marked a degree as completely to fill the inner extremity of the canal in some cases and prevent an inspection of the region of the atrium. This obstructing mass may be movable upon manipulation with the probe, and present many of the characteristics of granulation tissue. Impact with the probe shows that it is too firm and dense for granulation tissue. It does not bleed easily when touched, and, although movable, its attachment is broad. Careful inspection will usually enable us to make out that its surface is continuous with the supero-posterior canal wall, thus establishing its identity. The mass is exquisitely tender to pressure. Very little discharge is present, but the surface of the drum membrane and the adjacent walls of the canal are the seat of a desquamative process, and upon removing the epithelium, considerable serous transudation may take place, rendering exact diagnosis difficult. Inflation with the catheter or air bag reveals no perforation sound, the impact of the current being perceived as a dull, distant percussion sound, occasionally accompanied by bubbling râles. The conditions with which this may be confounded are the presence of exuberant granulations, from which we have already given the means of differentiation, and a circumscribed external otitis. This latter condition, we remember, usually affects the fibro-cartilaginous meatus, and after the speculum has once passed the orifice of the canal, the lumen appears of normal size. It may occasionally be mistaken for a diffuse external otitis, but here the canal is uniformly narrowed, the deeper portion of the postero-superior wall being affected no more prominently than its entire length. Tenderness over the mastoid region denotes an involvement of the pneumatic spaces, but a much better sign is the appearance already described in the canal. When, therefore, the appearance is indicative of a circumscribed otitis of the deep canal, we are to remember that this condition is almost pathognomonic of mastoid involvement, and are to proceed to treat the mastoid inflammation without delay.

Prognosis.—The cases in which discharge alone is the symptom almost invariably terminate favorably, often without treatment. If neglected, infection may take place, and a chronic purulent condition supervene. The occurrence of one attack probably renders the patient more prone to a similar process in future. In the cases attended by pain the condition is practically one of cellulitis, and should never be considered lightly. If left to itself, it may resolve spontaneously, or the fluid may escape into the atrium and then into the canal, or rupture may take place through the superior segment of the drum membrane. If spontaneous resolution does not take place, evacuation in either manner mentioned above seldom occurs before the bony parts are seriously involved, and a permanent discharge is a frequent outcome. If discharge does not take place, involvement of the mastoid cells or an extension to the intracranial contents, either by rupture or by infection through the venous channels, may occur. Concerning the effect upon audition, there is little danger that the function of the organ will be changed by such an intercurrent attack, the degree of impairment which was formerly present persisting but suffering no aggravation.

Treatment.—For the relief of the discharge, attention to cleanliness is all that is necessary. Irrigation with a mild solution of any of the well-known antiseptics, repeated as frequently as may be necessary to keep the canal free of discharge, is usually the only treatment required. This measure, in addition to cleansing the parts, causes a certain amount of depletion, which hastens resolution. In order that no secretion may remain in the middle ear, it is well to inflate by means of the air bag or by the Valsalva method before irrigation. In the early stages remedies directed toward stopping the discharge are contraindicated. When the more acute symptoms have passed away, if the discharge continues, we may follow each irrigation by the instillation of a solution of boric acid in alcohol in the proportion of twenty grains to the ounce, or a 1-to-3,000 solution of the bichloride of mercury dissolved in equal parts of alcohol, and water may be employed in the same manner. Occasional applications of metallic astringents—such as solutions of nitrate of silver, from two to twelve per cent—will frequently hasten the return to the normal condition. Where the discharge is small in amount but fails to cease entirely, we may discontinue irrigation altogether and rely upon insufflation of powders. Of these, nothing is better than boric acid, either alone or with the addition of iodoform, alum, iodol, etc. In making applications of this character, but a small quantity of the powder should be used, to avoid mechanical obstruction to any fluid which may be transuded.

If, in spite of intelligent treatment, the discharge continues, we are warranted in the supposition that the osseous structures have become involved, and relief will follow only the removal of the diseased bone. To guard against recurrent attacks, attention to the upper air passages is of the greatest importance. These recurrent cases usually occur in children under fifteen years of age, and in many instances we find that the vault of the pharynx contains an excessive amount of lymphatic tissue, while the faucial tonsils may also be hypertrophied. These conditions call for operative treatment, or topical applications, as may seem best adapted to the particular case. Any obstructive lesion in the nasal passages must also be overcome by operative or other methods.

Where the upper portion of the tympanic cavity is the seat of the process, the first indication is to relieve the pain, and at the same time to abort the local condition; or, if too far advanced for this, to evacuate the products of inflammation. To effect the first object, the patient should be put to bed and a full dose of opium or morphine administered, while at the same time local depletion should be employed. Undoubtedly the best method of attaining this end is a free incision through the upper part of the membrana tympani behind the short process of the malleus. This incision should extend from the last-named point backward to the canal wall, and may be continued outward upon its surface for from a sixteenth to a quarter of an inch; this I believe should be done whether any bulging is present or not. If fluid has already been effused and there are evidences of obstruction to its free discharge, the procedure is imperatively demanded. If this stage has not been reached, the local depletion will probably check its progress. If it does not seem advisable to incise the parts, the application of natural leeches or of the artificial leech in front of the tragus, removing from one to two ounces of blood, according to the age and condition of the patient, is the procedure to be employed. The application of cold to the mastoid is proper if there is the least suggestion of swelling along the posterior wall of the canal; irrigation of the parts with warm aseptic or antiseptic solutions should be begun at once, whether an incision has been made or not. If this has been done it will favor the hæmorrhage and render our efforts at aborting the attack more certain, while if no surgical measures have been instituted the combined effect of heat and moisture may so reduce the tumefaction as to permit the discharge of the fluid products through the atrium, or may possibly lead to resolution without the supervention of discharge. The internal administration of analgesics is contraindicated after the first twenty-four or thirty-six hours, as it serves only to mask the symptoms. If relief is not obtained at the end of this time, and surgical measures have been delayed, they must now be insisted upon, and a free section of the tissues involved must be made. The use of the ice coil should not be persisted in for more than forty-eight hours; if, in spite of its use, the pain continues severe and the mastoid is tender upon pressure, or even if there is no tenderness, if the postero-superior wall is depressed, the process has almost certainly extended to the pneumatic spaces of this structure, and operation should not be delayed. Regarding the value of Wilde's incision in these cases, I can only say that I never employ the measure. If the symptoms do not seem prominent enough to warrant the opening of the mastoid, incision of the overlying parts on its anterior surface, which forms the posterior and superior walls of the meatus, is the measure which will most probably give relief. It certainly possesses all the benefits of the external incision, both as regards the relief of tension and depletion, and may very properly be employed as a last resort before opening the mastoid process. In this class of cases I think we can not too strongly insist upon an early mastoid operation if the symptoms do not disappear promptly. The advantages of this are not only the immediate relief to the present condition, but also the certainty with which a subsequent chronic purulent otitis media is prevented. Unless checked by radical measures, the affection is almost certain to be followed by a chronic otorrhœa, although the present attack may be recovered from. Where an operation is performed early we usually avoid this, and the period of convalescence is much shortened. Another advantage is that recurrence is decidedly uncommon in cases operated upon, whereas those cases which recover without operation are specially prone to recurrence of the condition. Operations to obtain drainage through the meatus can not be advised; no doubt in some instances they are successful, but the engorgement of the parts is so great that the hæmorrhage must be considerable, and in the narrow field of operation this presents an almost insurmountable obstacle.

2. CHRONIC TYPE.

Under this term is comprised those cases whose symptoms depend upon the changes which have taken place as the result of persistent inflammation. These either remain constant or increase very slowly, according as the connective tissue developed as a result of the pathological condition is in a perfectly quiescent condition, or is slowly undergoing secondary sclerotic changes. The condition is comprised under the general term "rigidity of the ossicular chain," and the affection is by some authors denominated as "otitis media sclerotica." Owing to the increase in fibrous tissue within the middle ear, the entire ossicular chain is carried inward toward the internal wall; the foot plate of the stapes is crowded into the oval window, causing an increase in labyrinthine pressure, while at the same time the outward movement of the membrana tympani secondaria is impeded through a process of a similar character in this region. We have, then, the labyrinthine fluid subjected to a permanent increase in pressure. No doubt the equilibrium is partially restored by the passage of the fluid through the channels communicating with the subdural lymph spaces. Where the increase of pressure is but moderate in amount this may so far compensate for the inward movement of the stapes as to render the condition of equilibrium practically perfect, in which case no symptoms arise. More frequently the increased tension persists, producing in the early stages the symptoms characteristic of acute labyrinthine pressure, while at a later period evidences of atrophy of the terminal filaments of the auditory nerve manifest themselves, the continued pressure destroying these structures.

Pathology.—Following the same general classification of gross pathological appearances already described in treating of chronic purulent otitis media, it is not difficult to understand how in each individual class the action of the conducting chain in response to aërial vibrations is seriously interfered with. We may classify the interference with sound transmission in these cases as due to—

1. Simple œdema of the mucous membrane.
2. The presence of localized areas of hypertrophy due to chronic inflammation.
3. Adhesions either between the various members of the ossicular chain or between the malleus and incus and the internal tympanic wall.
4. Cicatricial bands in the membrana tympani. The membrana tympani itself may, as the result of a chronic inflammation, press the entire ossicular chain inward. This is specially true of cases in which a large portion of the membrane has been destroyed and the margin of the perforation coin-

cides with the posterior fold. A dense band frequently develops here, which crowds either the stapes or incus inward, causing serious impairment of function.

5 Adhesions limited to the region of the stapes. These adhesions develop either between the foot plate and the oval window, or between the crura and the walls of the pelvis ovalis, or from dense bands about the tendon of the stapedius muscle.

This classification, it is understood, is merely general; any of the conditions may exist singly, or several may be present in the same case. In general it may be said that the impairment in hearing and tinnitus undergo but little change in those cases where the functional disturbance is due to a deposit of new connective tissue either in the remnant of the membrana tympani or between the various ossicula themselves, or between the ossicles and the tympanic walls. Where the drum membrane is destroyed over a large area and the lining of the tympanic cavity is exposed, the power of audition frequently varies considerably at different times. Such changes usually depend upon congestion of the lining of the middle ear, or upon an accumulation of inspissated secretion in the deeper portions of the canal. In many of these cases, although there is apparently no discharge, the mucous membrane has not undergone complete dermoid transformation, and consequently continues to pour out a small amount of secretion. This becomes inspissated and collects most frequently in the upper and posterior quadrant directly over the stapes, and sometimes seriously interferes with the movements of the ossicle (Fig. 115). Those cases which suffer from frequently recurring attacks of congestion of the lining membrane of the middle ear with the production of a slight amount of discharge are prone to suffer from the development of exuberant granulations in the various portions of the tympanic cavity. This is particu-

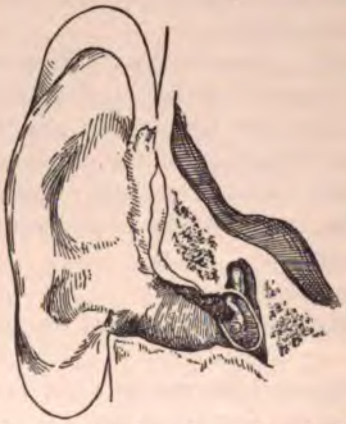


FIG. 115.—Inspissated secretion mixed with cerumen, covering a small perforation in the supero-posterior quadrant.

larly true where proper attention is not paid to cleanliness, the continued action of heat and moisture favoring the development of exuberant granulations.

Symptomatology.—The symptoms to which these changes give rise consist usually in an impairment of function of the organ, either to a considerable extent or only to a slight degree. As we have said before, impairment in hearing following purulent inflammation is less marked than when it occurs as the result of a nonsuppurative inflammation. The presence of subjective noises is not a symptom of as much importance in these cases, as they are seldom so prominent as to give serious discomfort, and unless specially inquired into may not be mentioned by the patient himself. Attacks of giddiness are occasionally complained of, usually following some manipulation about the ear, such as the insertion of some instrument into the canal for cleansing it, or the use of the syringe. In these instances we usually find that the head of the stapes is exposed. From the above classification of the affection we are now considering no discharge is present in these cases. The canal, however, is seldom perfectly free from foreign material. The exposed mucous membrane exfoliates its superficial epithelium, which accumulates within the meatus, or adheres to the walls as thin yellowish-white or brownish scales. These masses frequently adhere quite firmly to the walls of the meatus, and upon separating them a denuded area remains. The presence of this desquamated material, together with the moisture normally present in the canal, favors the development of the various forms of aspergillus, causing a slight discharge, or in severe cases an acute external otitis, with the attendant symptoms of pain, etc. The hearing is usually fairly constant, any variation from this condition being coincident with congestive changes in the upper air passages, as when the individual suffers from an acute coryza or from an acute naso-pharyngitis.

The development of cholesteatoma may manifest itself in cases which have remained quiescent for a long period. In certain cases the superficial epithelium of the canal migrates into the tympanic cavity and replaces the pavement epithelium of the mucous membrane. These epidermal cells are developed with unusual rapidity and as quickly thrown off. As the result, the tympanum is filled with a mass of epithelial cells which steadily increases in size and exerts great pressure upon the surrounding bony walls. The mastoid cells at a later period are invaded. The partitions between the pneumatic spaces are broken down, converting this series of small cavities into one large cavity.

Such a mass may produce no distinctive symptoms until the tympanum becomes acutely inflamed from some cause, when the sudden increase in volume due to the absorption of the products of the inflammatory process induces acute symptoms referable to the mastoid or middle ear.

Where a suppurative inflammation has existed for a long time a condensing osteitis of the mastoid not uncommonly occurs. This may continue after suppuration in the tympanum has ceased. The mastoid then becomes the seat of intense pain, either constant or paroxysmal, while neither the mastoid nor middle ear presents any evidence of acute inflammation. The possibility of such a process should always be borne in mind when persistent neuralgia of the mastoid region is met with in a subject who has suffered from a purulent otitis at any previous period.

In this connection it might be mentioned that in any case of persistent facial neuralgia of obscure origin the ear should always be examined. I have found in cases coming under observation for some aural affection, that frequently the treatment of the ear has arrested the attack of facial neuralgia, and the patients have of their own accord asseverated the facts.

It should be remembered that a suppurative inflammation in early infancy may leave no evidence in adult life except a minute pit or opening above the short process of the malleus. In these cases in particular the remains of the former affection may produce the symptoms in question.

Diagnosis.—A. *Physical Examination.*—The condition, as revealed by an examination of the parts, is of but little service in estimating the degree of impairment of hearing, or the relation between this impairment and the trouble present in the middle ear. It is only by a thorough functional examination in connection with minute ocular inspection that we can correctly judge as to how much of the interference with function depends upon the changes within the tympanum, as distinguished from that caused by the labyrinthine involvement.

B. *Functional Examination.*—Where the middle ear alone is affected, the examination by means of musical tones and the ordinary tests for hearing yields results characteristic of obstruction to sound conduction. These are elevation of the lower tone limit, very slight lowering of the upper tone limit, or no deviation from the normal standard, increased bone conduction, and, if one side alone is affected, a lateralization to the affected side of the vibrating tuning fork held upon the forehead in the median line. Moreover, the impairment is usually relatively greater for the voice than for sharp sounds, such as those of the watch or acoumeter. The degree of impairment for spoken or whispered words is proportionate to the height, in the musical scale, to which the relative duration of air and bone conduction is reversed, the inversion extending to the upper notes when the degree of impairment is marked, but affecting only the lower portion of the scale when this impairment is but moderate.

When the labyrinth has become involved we have, in addition to the evidences of interference with sound conduction, certain signs characteristic of changes in the lower portion of the cochlea. The upper tone limit is almost invariably lowered to a marked extent, usually below 20,000 V. D. Where the elevation of the lower tone limit remains the same as in uncomplicated cases, absolute bone conduction is usually diminished, and this is always the case when serious labyrinthine involvement is present. Occasionally it may be normal or increased. The tuning fork held upon the vertex is seldom lateralized to the poorer ear. The important diagnostic test is an observation of the relation between the impairment for whispered or spoken words and the position in the musical scale at which the reversal between air and bone conduction ceases. It will be found that where impairment is due chiefly to labyrinthine changes the impairment of hearing will be very marked, while the ratio between air and bone conduction will be reversed only for the very lowest notes. In such instances, even if the abnormal tension in the sound-conducting mechanism can be corrected, sufficient changes have taken place in the perceptive apparatus to render these measures of but little value in improving the hearing.

Prognosis.—The disease under discussion is usually more amenable to treatment than any other form of chronic tympanic inflammation. If left to itself, the majority of cases either do not progress at all, or deterioration is so slow as to enable us to promise that it will cause but little increased inconvenience in the future. A certain proportion of these cases improve spontaneously. This is particularly true in children or young adults, the continued massage of the parts by the sonorous vibrations to which they are subjected gradually stretching the adhesions or causing their resorption. After the age of thirty or thirty-five this probably never takes place spontaneously. After proper treatment the condition seldom recurs, and any improvement is likely to be permanent, it being more probable that the condition will even improve in subsequent years. The degree of improvement to be attained depends more upon the degree of labyrinthine involvement than upon any other one circumstance. If this is considerable, measures directed toward the middle ear probably aggravate the condition rather than benefit it. This is specially true of surgical measures. Certain cases come under observation on account of a sudden impairment of audition, and examination may reveal serious interference with the labyrinth. Where these changes are recent, measures directed to the middle ear are not contraindicated, since the disturbance within the labyrinth may depend upon some recent change in the sound-conducting mechanism which has not advanced to such an extent as to render the removal of the cause ineffectual in relieving the condition.

Treatment.—Where the symptoms depend upon swelling of the mucous membrane, measures directed toward the regulation of the habits of life especially are among the first indications. Next, the condition of the upper air passages should be thoroughly investigated and any obstructive condition corrected. This is particularly true where functional examination indicates labyrinthine interference, on account of the intimate relation between the venous return current from the labyrinth and that from the nasal passages. If these measures are not successful, topical applications to the lining membrane of the middle ear are to be instituted. These should be of mildly astringent character at first, the strength being increased if necessary. It is interesting in this connection to remark that although the membrana tympani may be almost completely destroyed, a restoration of the lumen of the Eustachian tube to its normal calibre will frequently relieve the symptoms. This depends, no doubt, upon the removal of obstruction to the venous return current from the tympanum. The condition within the Eustachian tube either may yield to simple inflation or may demand the use of some stimulating vapors, and in the more severe cases it may be necessary to resort to the bougie.

We should never lose sight of one fact, and that is the extreme susceptibility of these cases to the development of one of the vegetable molds. This may keep up a chronic congestion of the lining membrane of the middle ear in spite of the treatment already mentioned, and we should always be certain that the meatus is in a fairly aseptic condition in order that this factor may be eliminated. Where hypertrophic changes are more extensive and small aggregations of newly-formed tissue are found in any locality, these may be destroyed *in situ* either by the potential cautery or by chemical agents, but they are seldom large enough to be removed by means of the curette or snare. Occasionally a small crust will develop in the upper posterior quadrant, directly over the region of the oval or round windows, preventing the transmission of aërial vibrations to the labyrinthine fluid. Such an obstruction may be removed by the forceps, curette or syringe, as seems indicated in the particular case. It should be remembered that the removal of such a mass may be followed by a recurrence of the discharge, and it is wise to mention this fact to the patient before operating.

Where the tense margin of a remnant of the membrana tympani displaces the ossicles in any manner, the division of the fold by means of the knife is frequently followed by an astonishing improvement in function. The section can be made under cocaine anæsthesia, and if proper aseptic precautions are observed in preparing the field of operation, the procedure is followed by no discomfort. It is frequently necessary to repeat the section several times, the parts reuniting after division. They do not, however, unite throughout the entire length of the incision, and by repeating the procedure the tension is gradually relieved. When an obstructing band can not be exactly located in those cases where the entire ossicular chain remains, and other measures have failed to effect the desired improvement, it is wise to remove the remains of the membrana tympani, together with the two larger ossicles, thus exposing the round window and the stapes, the latter ossicle being dealt with according to the condition found upon inspection. This plan is advocated after considerable practical experience in cases of this character; and although relief is sometimes obtained by dividing rather blindly various constricting bands which lie beyond the field of vision, but are known to be present from the position which the ossicles assume, we seldom obtain sufficient amelioration to be satisfactory either to the surgeon or to the patient, and at length resort to the more complete operation already mentioned. It is wise, therefore, to make this the operation of election, and to eliminate thoroughly all interference with tension in the conducting chain at a single operation.

Where the stapes is exposed, the incudo-stapedial articulation having been destroyed, several plans of treatment are open to us. The simplest is auto-mobilization, by inserting an artificial drum membrane, such as a small disk of paper or a small pledget of cotton. This is applied with the forceps or cotton holder, so as to rest upon the head of the stapes, and, by increasing the surface presented for the reception of aërial vibrations, causes them to exert a more powerful force upon the stapes. Decided improvement has followed this plan in several cases. Where manipulation by means of the probe shows that the stapes is firmly fixed, it is well to break up these adhesions by manipulation, the knife being employed to divide the more dense bands if necessary. The technique of these operations will be described in a chapter devoted to the operative surgery of the middle ear.

Concerning the advisability of the extraction of the stapes good results have been obtained in these residuary cases. It is a question in my mind, however, whether we can not obtain similar, or even better, results by leaving the stapes in place and mobilizing it mechanically; for, although I have removed it a number of times with good results, I have, in cases presenting similar symptoms and responding in the same manner to functional tests, seen no improvement whatever follow the operation. If the entire stapes can be removed, it can certainly be mobilized, and the foot plate probably transmits the sonorous waves to the labyrinth more perfectly than does the cicatricial membrane which is formed after its removal. Where ossification at the stapedio-vestibular articulation has taken place, the removal of the part piecemeal may be attempted. This procedure is effected either by means of a sharp spoon or by a small burr, which wears away the thin, bony lamella separating the labyrinth from the tympanum.

The burr should be conical in shape and so guarded as to prevent its entering the labyrinth more than a millimetre, when the foot plate is perforated.

Adhesions about the round window can seldom be seen, but their presence may be suspected when the niche of the fenestra rotunda is surrounded by hypertrophied mucous membrane. Stellate incision, by means of an angular knife inserted into the niche, will relieve tension here, and is frequently followed by improvement in connection with operative procedures about the oval window. Concerning any aggravation of symptoms which surgical measures may induce, I can only say that their occurrence is very rare, if we bear in mind the rule that when serious labyrinthine disturbance is present operative measures are contraindicated.

Where the labyrinth is involved the internal administration of pilocarpine often relieves the tension and is followed by an amelioration of the symptoms. After this has occurred, if functional examination indicates that the tympanic lesion is a competent cause of the interference with function, operative measures now become proper. Where the residual condition is present in but one ear, the effect upon the organ of the opposite side is always to be borne in mind. If the opposite ear becomes affected, the changes first met with are usually labyrinthine in character, and operative measures may be indicated for the preservation of the sound organ, although the ear operated upon may be beyond relief. It is sometimes stated that interference in these residuary cases may be followed by a recurrence of the discharge, but it has never been my experience to witness this. A discharge from an ear which is the seat of a residual process can depend only upon the presence of some foreign body; and no operative measures, if properly carried out, would lead to the development of this condition—that is, to the development of bony necrosis.

IV. DISEASES OF THE MASTOID PROCESS.

CHAPTER XXIV.

THE ANATOMY OF THE MASTOID PROCESS.

IN considering the anatomy of the ear a detailed description of the mastoid process was not given, it seeming wiser to incorporate the necessary details in the section on Diseases of the Mastoid. The mastoid portion of the temporal bone is an irregular conical mass of osseous tissue located behind the external auditory meatus and projecting for a varying distance below the level of its floor. Its lower extremity, forming the apex of the cone, is covered by the aponeurosis of the sterno-mastoid muscle. This muscle is attached not only to the tip of the process, but also for a considerable distance along its internal aspect. Above the insertion of the muscle upon the internal surface of the mastoid is a deep furrow, the digastric groove, which lodges the occipital artery and furnishes attachment for the posterior head of the digastric muscle. This bony mass may be pneumatic, diploïc, or sclerotic in structure. In the pneumatic mastoid (Fig. 116) there are numerous air spaces throughout the entire mass; these are irregularly distributed, in some cases lying almost immediately below the cortex, while in other instances they are situated at considerable depth below the outer surface of the bone and are specially numerous upon its anterior aspect; this anterior wall of the mastoid forms the posterior

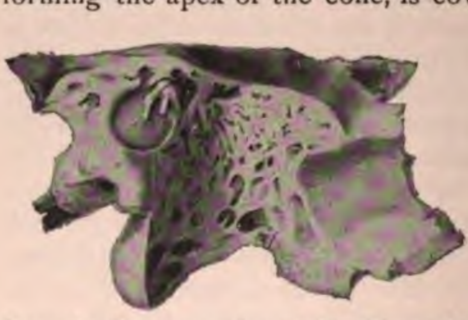


FIG. 116.—The pneumatic mastoid. The section shows the relative position of the tympanic vault and mastoid antrum to each other and to the intracranial surface. (Author's specimen.)

wall of the external auditory canal, and when the cells are well developed in this region the earliest evidences of their involvement in an inflammatory process appears here. One pneumatic space is constant, and that is the antrum. This cavity is irregularly pyramidal in shape, communicates with the tympanic vault by a narrow passage, and varies considerably in size in different individuals. At birth the antrum is the only space developed, the others being formed subsequently. We not infrequently find a second cell of considerable size located at the very tip of the process; the outer bony wall of this space is often very thin—a fact which is of considerable clinical importance. The root of the zygoma is also frequently found exceedingly pneumatic.

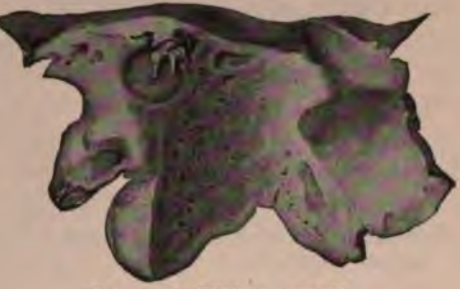


FIG. 117.—Diploïc mastoid.

In the diploïc mastoid the antrum alone is present, the remaining portion consisting of diploïc tissue, similar to that found in the other cranial bones (Fig. 117).

Where the mastoid is sclerotic the entire process consists of a dense eburnated mass of osseous tissue; its structure is uniform throughout, presenting not even the slightest vestige of a pneumatic space, with the exception of the antrum, and even this may be of small size.

Various combinations of these three forms may be met with in individual cases; thus a sclerotic process may have progressed to a certain point and ceased spontaneously, in which event the trabeculæ will be firmer than normal and the pneumatic spaces of small size; or but one or two air cells may exist, the remaining portion being diploïc in structure.

Owing to the invariable presence of the mastoid antrum, its location is a matter of importance. It is best located by bearing in mind its relation to the superior and posterior walls of the external auditory meatus. If two lines be drawn—one horizontal, tangent to the superior wall of the external auditory canal, the second vertical and tangent to its posterior wall—the point of their intersection will be the apex of a triangle the base of which will be formed by that portion of the curvilinear outline of the meatus included between the points of tangency of these lines. This triangle lies immediately over the antrum and an artificial opening within this space will enter the cavity.

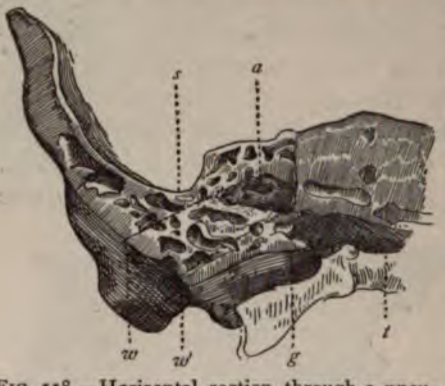


FIG. 118.—Horizontal section through a pneumatic mastoid. *s*, Groove for lateral sinus; *a*, Mastoid antrum; *t*, Tympanic cavity; *g*, Posterior wall of external canal; *w*, *w'*, Path of instrument from surface of mastoid to antrum. (Politzer.)

Another cell which is fairly constant is that large pneumatic space located at the tip of the apophysis. The outer bony wall of this cavity on the digastric surface of the mastoid is often no thicker than parchment, and where the mastoid is the seat of an inflammatory process attended by the formation of pus, the involvement of this large space may be first evidenced by the presence of diffuse tumefaction near the mastoid origin of the sterno-mastoid muscle, either on the external surface or more usually in the digastric fossa, in which case the tumefaction lies immediately beneath the body of the muscle.

The relation which the mastoid bears to the intracranial contents is of importance in the performance of surgical operations in this region. The topographical relations between the mastoid and the tympanum and cranial fossæ are best considered together, since operative procedures upon the mastoid process are usually demanded because of some abnormal condition within the tympanum, and this cavity is always entered at the time of operation. The roof of the tympanum is formed by the petro-squamous suture and supports the temporo-sphenoidal lobe of the cerebrum. The vault of the tympanum and mastoid antrum, then, are in

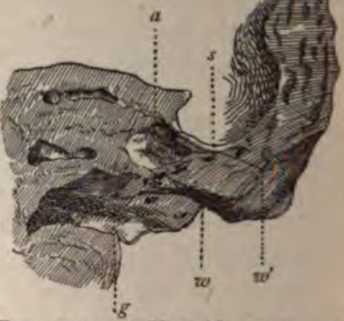


FIG. 119.—*a*, Mastoid antrum; *s*, Groove for lateral sinus; *g*, Posterior wall of external canal; *w*, *w'*, Path of instrument from surface of mastoid to antrum. (Politzer.)

relation above to the middle cranial fossa; hence any product of inflammation passing through the roof of the tympanum enters this portion of the cranial cavity, after which its conveyance along the superior surface of the petrous portion of the temporal bone to the region of the medulla is exceedingly simple. As the mastoid antrum is but an extension backward of the vault of the tympanum, its intracranial relations are the same as are those of the tympanic vault. The mastoid cells are also in relation with the meninges of the posterior cerebral and the cerebellar fossæ. In cases of intracranial involvement complicating mastoid inflammation, the process is usually confined to meninges covering the posterior cerebral lobe or the cerebellum. When extension takes place through the roof of the tympanum the contents of the middle cranial fossa is usually involved.

The internal surface of the mastoid process presents a deep groove for the lodgment of the lateral sinus. The distance which this vessel may extend into the mastoid varies in individual cases; usually it lies behind the antrum, and in some instances the bend of the sinus is so sharp that the acute angle extends forward so as to lie but a short distance behind the posterior wall of the external auditory meatus, and may be so near the surface of the process as to cover the antrum (see Fig. 120). It is evident that with the sinus in this position an artificial opening into the antrum could not be made at the site of election for entering this cavity without exposing or wounding this large venous channel. In Fig. 118 the parts are so placed that the sinus is in no danger, while in Fig. 119 it could be avoided with care.

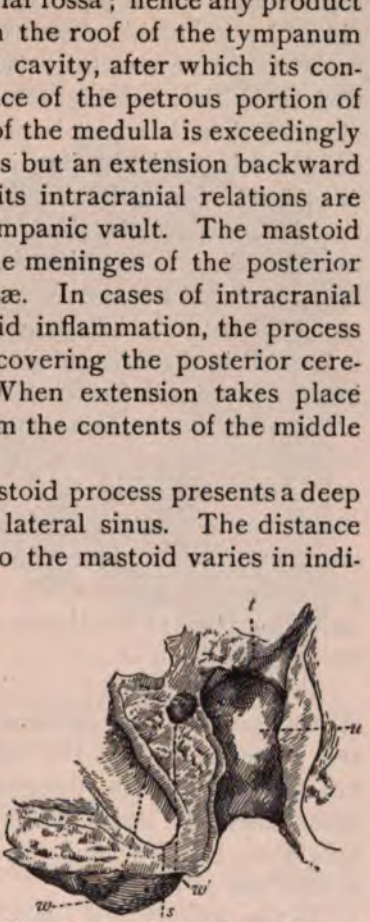


FIG. 120.—*t*, Tympanic cavity; *u*, Floor of external meatus; *s*, Groove for lateral sinus; *w*, *w′*, Path of instrument from surface of mastoid to antrum. In this case the sinus would be wounded in the operation. (Politzer.)

An examination of numerous specimens has been made by both Körner * and Randall † for the purpose of determining whether the location of the sinus could be positively decided by external measurements of the skull. These researches prove conclusively that external measurements are useless in determining the site of the sinus. This venous channel, then, bears an important relation to the mastoid process, and its variable situation must always be borne in mind in operative procedures. When, for any reason, it seems desirable to expose the sinus during an operation, it can be done by extending the opening in the bone backward, care being taken to avoid the removal of any bone beyond the occipito-temporal suture. The groove lodging the knee of the sinus is located in the mastoid process, and an extension of the opening to the point of junction between the occipital and temporal bones affords abundant space for examination of the sinus as well as of the condition of the posterior cranial fossa both above and below the tentorium. This statement regarding the extensive removal of bone in exposing the sinus may seem unnecessary, but where the patient is anæmic the exposed sinus may be nearly empty and its walls may be of the same color as the contiguous meningeal surface, rendering its recognition difficult.

---

* Arch. of Otol., vol. xviii, p. 310.

† Trans. of the Amer. Otol. Society, 1892, p. 235.

From the presence of this vessel it is advisable in all operations upon the mastoid first to remove the cortex as close to the posterior wall of the canal as possible. After the cells are entered and the topography of the particular process is ascertained, the opening may then be enlarged as much as is necessary, but the cavity should always be entered as close to this line as possible.

In the majority of cases the middle cranial fossa lies at a considerably higher level than the horizontal plane passing through the superior wall of the bony meatus. The location of the floor of this space is commonly above the plane passing through the temporal ridge, this last term being applied to the prolongation of the roof of the zygoma backward over the entrance of the external auditory canal. The temporal ridge was for a time considered the upper limit of safety in opening the mastoid process. Occasionally, however, we meet with cases in which the squamous portion of the temporal bone, instead of lying almost vertical, is considerably inclined, forming an acute angle with the horizontal plane. When this occurs the temporal ridge overhangs the entrance to the meatus (Fig. 121). Unless care is exercised, the superior margin of the canal will not be correctly located, the prominent ridge being mistaken for it. It will easily be seen that if the chisel is now applied over what seems to be the area ordinarily selected for perforating the cortex, the opening will be situated above the mastoid antrum, and the middle cranial fossa will be entered. Care should be taken, therefore, to recognize this anomaly, and to be certain that the superior margin of the canal is really exposed before the bone is perforated. In young children this prominence of the temporal ridge is a usual condition, owing to the exceedingly oblique angle between the squama and the auditory plate (Figs. 6 and 122).

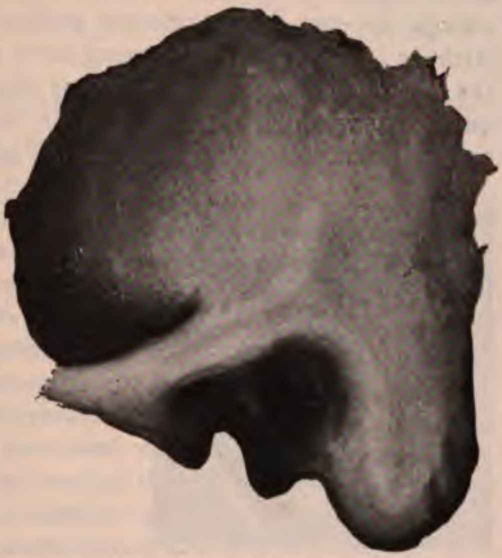


FIG. 121.—Adult temporal bone in which the temporal ridge overhangs the entrance to the canal. (Author's specimen.)

In the infant at birth the mastoid is but poorly developed, consisting usually of but a single cell—the antrum. It must be remembered, however, that there is a very large pneumatic space in immediate relation to the tympanic cavity, as the vault of the tympanum in the child is nearly as large as in the adult, the ossicles increasing but little in size from the period of birth to adult life. This, no doubt, explains the cause of the pronounced symptoms found in even the simpler inflammations of the middle ear in infancy and early childhood. The inner table of the cranium is excessively thin, and frequently incomplete in places along some of the sutural lines. The vascular supply of the lining membrane of this pneumatic space, made up of the vault of the tympanum and of the mastoid antrum, is very free and in close anastomotic relation with the intracranial venous sinuses. For this reason symptoms of meningeal irritation are frequently observed, even in a mild attack of otitis media in infancy. Again, a fatal termination is probably more common than we are aware, due to an early thrombosis of the venous sinuses, or to septic meningitis. These may occur even before discharge appears in the external auditory meatus, and perhaps without special attention having been called to the ear, unless the physician is aware of the fact that one of the most frequent causes of high temperature in young infants is a middle-ear inflammation. A reference to Fig. 122, which is a drawing of a specimen in the possession of the author, shows how capacious this pneumatic space may be at birth.

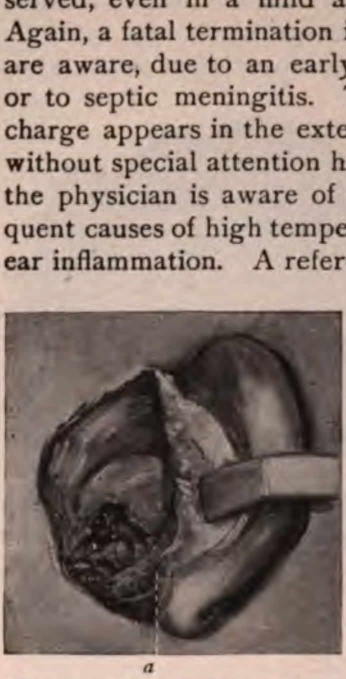


FIG. 122.—The tympanic vault and mastoid antrum at birth. *a*, External canal separated from surface of squama. At its inner extremity is the membrana tympani inclosed by the tympanic ring. Above the ring the malleus and incus are plainly seen. (Author's specimen, natural size.)

The depth at which the mastoid antrum lies varies in different cases. It is seldom entered at a depth of less than half an inch, and may lie seven eighths of an inch below the external surface. The only structure of importance lying within the mastoid process itself is the facial nerve, which passes out through the stylomastoid foramen. The nerve crosses the upper portion of the tympanic cavity in the aquæductus Fallopii, and leaves the cavity through an opening in the posterior wall. In the mastoid its course is downward, outward, and slightly backward, crossing the line of the posterior canal wall at the junction of the lower and middle third. Since it is deeply placed and the bony wall covering it is so dense, it is seldom wounded, and a little care will enable the operator to avoid it. Immediately above the aquæductus Fallopii we find the horizontal semicircular canal. This structure can be injured only by continuing the artificial opening beyond the level of the internal wall of the tympanum, an accident which need not occur if ordinary care is exercised. The same may be said of wounding the facial nerve in its passage through the aqueduct.

CHAPTER XXV.

INFLAMMATION OF THE MASTOID PROCESS.

Ætiology.—The most common cause of an acute inflammation in this region is an extension of a similar process from the middle ear. The primary lesion may be either acute or chronic in character, although it is probable that a simple catarrhal inflammation does not involve the mastoid process by extension. In cases where the mastoid is involved, during the course of what has seemed to be a catarrhal inflammation, it is believed that the process within the middle ear has already changed in character and that the involvement of the mastoid has occurred at a very early stage on account of the intensity of the process, which has attacked not only the middle ear, but the communicating pneumatic chamber as well.

Primary mastoiditis, although uncommon, is occasionally seen, and may follow an exposure to cold or a traumatism, or may be a manifestation of a tubercular or specific diathesis. When syphilis is the cause of a primary mastoiditis, there is a gummatous deposit in the mastoid, which subsequently breaks down in the characteristic manner. Inflammatory conditions within the meatus may also extend to the mastoid by contiguity. A simple circumscribed inflammation may produce this result, especially when located upon the posterior wall of the canal. Diffuse external otitis may cause a similar condition. An acute suppurative inflammation of the middle ear is the most common cause of an acute mastoiditis. Chronic suppuration within the tympanic cavity may also cause an acute inflammation within the mastoid. It is curious that a purulent inflammation may exist for years within the middle ear without producing any symptoms referable to the mastoid. From some exciting cause, frequently so trivial in character as to be unrecognized, acute mastoid symptoms may suddenly supervene.

Pathology.—It is probable that in every case of acute inflammation of the middle ear, the mastoid cells are involved to a certain extent. It is only in those cases where severe infection has taken place, or drainage through the middle ear is postponed, that suppurative mastoditis follows an acute infection. A chronic suppuration within the middle ear causes certain changes within the mastoid process, as the result of which the pneumatic structure gradually disappears, and the mastoid becomes sclerotic to a greater or less extent. Instead of these hypertrophic changes, with the deposit of new bone, the opposite result may take place. Bony necrosis may occur, and a large sequestrum may be formed within the mastoid process. If the destruction within the mastoid is but moderate in amount, no sequestrum may be formed, but the detritus may gradually be discharged through the external auditory meatus in the form of pus. Therefore a profuse purulent discharge from the external auditory canal is one of the best signs of involvement of the mastoid process.

The presence of infectious material within the bony cavity may produce several results; the simplest, already mentioned, is a copious otorrhœa. If drainage through the canal is impeded, the fluid must find exit, and evacuates itself spontaneously where the least resistance is offered. This may be—

1. Through the external mastoid cortex, either behind the ear or in the external meatus.
2. Through the cortex in the digastric fossa.
3. Through the root of the zygoma.
4. Through the roof of the antrum, or of the tympanic vault, into the middle cranial fossa.
5. Into the posterior cranial fossa, usually by rupture into the groove lodging the lateral sinus.

When the cranial cavity is invaded we have an inflammation of the meninges, which may be diffuse or circumscribed. In the former condition a purulent leptomeningitis results, while in the latter an epidural abscess is formed. The production of an epidural abscess seems to be an effort on the part of Nature to limit the inflammation to a circumscribed area, the infectious material being walled in on all sides by adhesions between the dura and the adjacent osseous walls. Internal rupture is not the only manner in which the contents of the cranial cavity may be invaded; the free anastomosis between the blood vessels of the dura and the pericranium may furnish the avenue through which the infectious material may pass to the intracranial contents. In this manner we may have, in addition to the two conditions already mentioned, a thrombosis of the lateral sinus, or an abscess within the brain substance. Unfortunately for the patient, these lesions, instead of being single, frequently occur together; thus a sinus thrombosis without considerable meningitis is rare, while a brain abscess is a not infrequent accompaniment of thrombosis of the sinus.

Where rupture takes place upon the external surface of the mastoid, it is commonly supposed that all serious danger of involvement of the intracranial contents is at an end, although the abscess may not be immediately evacuated by incision of the overlying soft parts. This is an error, particularly in the case of children. Here the sutural lines between the various portions of the temporal bone are not completely ossified, and when the external surface of the temporal bone is bathed in pus, infection, either through the sutural lines or through the substance of the squama itself, is by no means impossible.

I have reported one case of this character in a child and one in an adult,* while several other instances may be found in otological literature. In children the presence of pus beneath the integument in the post-aural region does not of necessity indicate a perforation through the cortex. In these young subjects a collection of fluid within the tympanic vault frequently makes its way along the superior wall of the canal, gaining exit from the cavity through the Rivinian segment by dissecting the soft parts away from the bone in this location. In very young infants this is by no means uncommon, while in children over ten years of age it is occasionally met with. Perforation of the cortex on the anterior surface—that is, through the posterior wall of the bony meatus—may occasionally occur. Spontaneous evacuation here is probably due to the fact that in the particular case the external cortex is thicker, while along the posterior aspect of the canal the pneumatic cavities are well developed and thin-walled. Where sequestra are formed the process does not differ, except that in addition to the fluid collection we have a foreign body whose action is to aggravate the changes already described. The same remark applies to the development of a cholesteatomatous mass within the mastoid cells. These epithelial collections are rather prone to excite a hyperplastic inflammation, terminating in sclerosis with obliteration of the trabeculæ between the cells. It is only when the mass attains considerable size that acute inflammatory changes are set up, producing a train of symptoms characteristic of an acute process in this region.

---

* Archives of Otology, vol. xxi, p. 253.

The cholesteatomatous deposit may attain such a size as to cause absorption of the posterior wall of the canal, converting the mastoid, antrum, tympanum, and bony meatus into a single cavity. At the same time the cortex of the mastoid is often sclerosed.

Symptomatology.—The prominent symptom met with is intense pain over the mastoid portion of the temporal bone. The pain is particularly severe at night, preventing sleep. It is of dull character, deep-seated and constant. Following a painful inflammation within the tympanum, a change in the character and location of the pain complained of by the patient is a valuable symptom. The degree of constitutional disturbance presented is often entirely out of proportion to the local changes. The patient may be well nourished, the temperature normal, and the pulse but slightly accelerated, while at the same time extensive destruction is taking place. Where the disease complicates an acute process within the middle ear, or is primary in character, the temperature is usually elevated, varying from 99.5° to 101.5°, but seldom higher than this, except in children where a persistent elevation of temperature may be the only symptom of mastoid involvement. Where the cells are well developed at the apex, considerable difficulty may be experienced in moving the head from side to side. In children this symptom should always be carefully investigated, although no pain may be complained of in the region of the ear. Tenderness upon deep pressure is probably the most characteristic sign of the involvement of the osseous structures. This varies considerably in location. It is usually most marked directly over the antrum and close to the posterior margin of the canal. Occasionally the most tender point will be found at the tip of the apophysis. The aural discharge usually becomes scanty when mastoid symptoms develop. On the other hand, a continuous, profuse discharge is clearly indicative of mastoid involvement. A profuse discharge of long duration could not come from the middle ear alone. In young children who are unable to locate exactly the seat of pain, restlessness at night should always excite suspicion if it follows the cessation of a profuse aural discharge. Tumefaction behind the auricle in not common, except in early life. Œdema of the overlying soft parts is more characteristic of an inflammation within the canal than of involvement of the mastoid process. Fluctuation, it need hardly be said, indicates spontaneous evacuation of the purulent contents.

If the intracranial structures are involved, the symptoms manifested depend upon the particular region attacked. If one of the large venous sinuses becomes the seat of an infectious thrombus, the temperature changes are the most characteristic evidence of the condition. They consist in the sudden elevation of the temperature, the thermometer frequently registering 104° or 105°. This elevation persists but for a few hours, and is followed by a spontaneous fall to the normal standard or even lower than this. These intermittent elevations may occur several times during the day, and may be of such short duration as to be unrecognized unless the temperature is taken frequently. Following the access of the fever there is profuse perspiration, and as the condition advances, well-marked symptoms of general sepsis appear. The patient becomes very weak. The skin is of a dull, ashy hue, the pulse feeble, and the mental condition dull, all of which are indicative of profound systemic infection. If emboli are developed, their lodgment in the various viscera is followed by characteristic symptoms. The most common site of lodgment is probably the lungs, causing a septic pneumonia. When the thrombus develops in the lateral sinus it frequently extends downward into the internal jugular vein, and its presence is revealed by deep tenderness along the course of this vessel, together with tumefaction along the anterior border of the sterno-mastoid muscle. Whenever temperature changes excite suspicion of involvement of the sinus, the region of the external jugular vein should be examined frequently for confirmatory signs. The sensorium is seldom disturbed, except just before death, where thrombosis alone is present.

Where involvement of the intracranial structures results in diffuse meningitis, we have intense headache, photophobia, a high temperature which remains constant, nausea, and vomiting. Otitic meningitis usually involves the base of the brain rather than the convexity. Hence a slow pulse characteristic of traumatic meningeal inflammation is wanting, the cardiac action being increased in rapidity. Paralysis of individual muscles soon appears, the third and sixth nerves being most frequently involved, causing either strabismus or paralysis of the ciliary muscle. Rigidity of the muscles of the neck occurs quite early, and is one of the most characteristic symptoms.

Where the meningitis is localized, constituting an extradural abscess, the temperature is usually but moderately elevated, seldom exceeding 100°. The characteristic symtom is localized headache, the painful region corresponding pretty closely to the area involved. Paralytic symptoms do not appear until late in the course of the disease. Rigidity of the muscles of the neck, vomiting and photophobia are also absent.

The occurrence of an abscess within the cerebral substance is a rare accompaniment of acute mastoid inflammation. It may be said it produces no symptoms which may be called characteristic until it has attained sufficient size to press upon some portion of the motor tract. Its presence should always be suspected when there is a persistent low temperature, together with constant headache, increasing asthenia, and progressive hebetude. So far from producing characteristic symptoms, it is rather the absence of any characteristic manifestation, but the failure of the patient to improve, which should always excite suspicion of this condition. When in an acute mastoiditis the pain diminishes in severity and assumes the character of a general headache, while at the same time the patient becomes progressively dull and unobservant of his surroundings, the temperature remaining normal or but slightly elevated, invasion of the cerebral substance should be suspected. The occurrence of two or more of these intracranial conditions in association is what renders a diagnosis difficult. A brain abscess is not an uncommon complication of a thrombosis of one of the large venous channels. The thrombus causes the characteristic intermittent temperature and masks the purulent collection situated deeply within the cerebral tissue. It is also common to find considerable meningitis with either cerebral abscess or thrombosis of the lateral sinus. This local inflammation prevents the temperature from intermitting, as we should expect it to do if the sinus alone were involved, and the fever due to meningitis may render the fluctuations due to the entrance of infectious material into the circulation at frequent intervals entirely unrecognizable.

Diagnosis.—It would seem that the recognition of the invasion of the osseous structures immediately surrounding the tympanum would be a matter of simplicity, and quite frequently no difficulty is experienced in making a diagnosis. On the other hand, we meet with cases in which even the most expert observer must be in doubt as to whether the pneumatic cells of the mastoid have become infected, or whether the severe constitutional symptoms are due simply to the conditions within the tympanum. There are two signs upon which the most dependence can be placed, and the presence of both is a certain indication of mastoid involvement, while the presence of either one alone is certainly suspicious and often constitutes the sole sign upon which the necessity of operative treatment is based.

These two signs are:

1. Local tenderness upon deep pressure over the mastoid region.
2. A depression or sagging of the supero-posterior wall of the canal close to the tympanic ring.

In determining mastoid tenderness care must be taken to be sure that the pain experienced by the patient upon manipulation is really mastoid tenderness, and does not depend upon an inflammation of the external canal. No error need occur if, when the examination is made, the examining finger is pressed backward and inward upon the mastoid just behind the insertion of the auricle, since this manipulation does not move the fibro-cartilaginous canal. On the other hand, if the finger of the operator causes even the slightest movement of the auricle or of the meatus, the presence of an external otitis may lead to error.

The tender point is usually situated over the antrum, and may be close to the margin of the bony meatus; even here it is not necessary to cause the slightest motion of the soft parts if the thumb be placed upon the margin of the bony ring and pressure exerted backward and inward. The tenderness elicited is unmistakable, the patient not infrequently cringing at the moment when the parts are pressed upon. It is always wise to test the healthy mastoid in the same manner, since a certain number of individuals possess what may be called a physiological tenderness of the mastoid process. This is ing whether the location of the sinus could be positively decided by external measurements of the skull. These researches prove conclusively that external measurements are useless in determining the site of the sinus. This venous channel, then, bears an important relation to the mastoid process, and its variable situation must always be borne in mind in operative procedures. When, for any reason, it seems desirable to expose the sinus during an operation, it can be done by extending the opening in the bone backward, care being taken to avoid the removal of any bone beyond the occipito-temporal suture. The groove lodging the knee of the sinus is located in the mastoid process, and an extension of the opening to the point of junction between the occipital and temporal bones affords abundant space for examination of the sinus as well as of the condition of the posterior cranial fossa both above and below the tentorium. This statement regarding the extensive removal of bone in exposing the sinus may seem unnecessary, but where the patient is anæmic the exposed sinus may be nearly empty and its walls may be of the same color as the contiguous meningeal surface, rendering its recognition difficult.

From the presence of this vessel it is advisable in all operations upon the mastoid first to remove the cortex as close to the posterior wall of the canal as possible. After the cells are entered and the topography of the particular process is ascertained, the opening may then be enlarged as much as is necessary, but the cavity should always be entered as close to this line as possible.

In the majority of cases the middle cranial fossa lies at a considerably higher level than the horizontal plane passing through the superior wall of the bony meatus. The location of the floor of this space is commonly above the plane passing through the temporal ridge, this last term being applied to the prolongation of the roof of the zygoma backward over the entrance of the external auditory canal. The temporal ridge was for a time considered the upper limit of safety in opening the mastoid process. Occasionally, however, we meet with cases in which the squamous portion of the temporal bone, instead of lying almost vertical, is considerably inclined, forming an acute angle with the horizontal plane. When this occurs the temporal ridge overhangs the entrance to the meatus (Fig. 121). Unless care is exercised, mal conditions, and when the parts adjacent are œdematous from inflammation complete obstruction is frequent.

In addition to these two signs there is usually severe pain, especially at night; or, if not pain, sleeplessness; the last symptom is especially noticeable in chronic cases. To these patients the mastoid pain or headache has become a second nature, and a slight increase does not produce the same effect as the corresponding condition in a previously healthy individual, but leads to loss of sleep. Body temperature has practically no diagnostic value; in acute cases we usually find an elevated temperature varying from 100° to 102° or 103°. Where the middle ear has been the seat of a suppurative process for a long period, the mastoid subsequently becoming involved, it is not infrequent to find the temperature perfectly normal, although the temperature is taken so frequently as to preclude the possibility of any rise being overlooked. Local œdema behind the ear is more characteristic of a circumscribed inflammation of the canal than of mastoid involvement. In young children, where the bony meatus is not developed, tumefaction behind the ear is frequently found, and evacuation of the abscess may occur, although no perforation through the cortex is present. The fluid within the mastoid burrows along the postero-superior canal wall, and appears close behind the auricle quite early, owing to the ease with which it finds an exit through the Rivinian segment. In children, also, the cortex of the mastoid is exceedingly thin, and perforation may take place in twenty-four hours after the onset of an acute attack and produce the characteristic physical evidences. A condition which should never be forgotten is the occasional rupture of a mastoid abscess upon the internal surface through the digastric fossa. Here local tenderness over the antrum may be absent, the pain being referred to the lateral cervical region. In the early stages careful examination may reveal no difference between the corresponding regions of the sound and diseased side. At a later period a diffuse, brawny swelling is made out beneath the sterno-cleido-mastoid muscle, extending for a considerable distance both in front and behind it, the limits being poorly defined. Deep pressure over the tip of the mastoid elicits pain, which is frequently considered to be neuralgic in character, and depending upon the middle-ear lesion. Rupture at this point is rather characteristic of cases served, even in a mild attack of otitis media in infancy. Again, a fatal termination is probably more common than we are aware, due to an early thrombosis of the venous sinuses, or to septic meningitis. These may occur even before discharge appears in the external auditory meatus, and perhaps without special attention having been called to the ear, unless the physician is aware of the fact that one of the most frequent causes of high temperature in young infants is a middle-ear inflammation. A reference to Fig. 122, which is a drawing of a specimen in the possession of the author, shows how capacious this pneumatic space may be at birth.

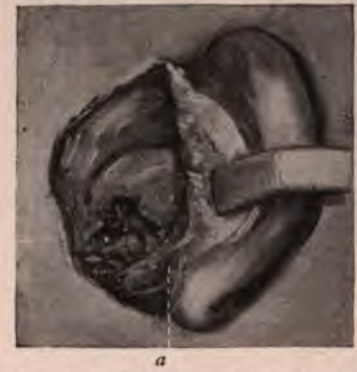


FIG. 122.—The tympanic vault and mastoid antrum at birth. *a*, External canal separated from surface of squama. At its inner extremity is the membrana tympani inclosed by the tympanic ring. Above the ring the malleus and incus are plainly seen. (Author's specimen, natural size.)

The depth at which the mastoid antrum lies varies in different cases. It is seldom entered at a depth of less than half an inch, and may lie seven eighths of an inch below the external surface. The only structure of importance lying within the mastoid process itself is the facial nerve, which passes out through the stylomastoid foramen. The nerve crosses the upper portion of the tympanic cavity in the aquæductus Fallopii, and leaves the cavity through an opening in the posterior wall. In the mastoid its course is downward, outward, and slightly backward, crossing the line of the posterior canal wall at the junction of the lower and middle third. Since it is deeply placed and the bony wall covering it is so dense, it is seldom wounded, and a little care will enable the operator to avoid it. Immediately above the aquæductus Fallopii we find the horizontal semicircular canal. This structure can be injured only by continuing the artificial opening beyond the level of the internal wall of the tympanum, an accident which need not occur if ordinary care is exercised. The same may be said of wounding the facial nerve in its passage through the aqueduct.

CHAPTER XXV.

INFLAMMATION OF THE MASTOID PROCESS.

Ætiology.—The most common cause of an acute inflammation in this region is an extension of a similar process from the middle ear. The primary lesion may be either acute or chronic in character, although it is probable that a simple catarrhal inflammation does not involve the mastoid process by extension. In cases where the mastoid is involved, during the course of what has seemed to be a catarrhal inflammation, it is believed that the process within the middle ear has already changed in character and that the involvement of the mastoid has occurred at a very early stage on account of the intensity of the process, which has attacked not only the middle ear, but the communicating pneumatic chamber as well.

Primary mastoiditis, although uncommon, is occasionally seen, and may follow an exposure to cold or a traumatism, or may be a manifestation of a tubercular or specific diathesis. When syphilis is the cause of a primary mastoiditis, there is a gummatous deposit in the mastoid, which subsequently breaks down in the characteristic manner. Inflammatory conditions within the meatus may also extend to the mastoid by contiguity. A simple circumscribed inflammation may produce this result, especially when located upon the posterior wall of the canal. Diffuse external otitis may cause a similar condition. An acute suppurative inflammation of the middle ear is the most common cause of an acute mastoiditis. Chronic suppuration within the tympanic cavity may also cause an acute inflammation within the mastoid. It is curious that a purulent inflammation may exist for years within the middle ear without producing any symptoms referable to the mastoid. From some exciting cause, frequently so trivial in character as to be unrecognized, acute mastoid symptoms may suddenly supervene.

Pathology.—It is probable that in every case of acute inflammation of the middle ear, the mastoid cells are involved to a certain extent. It is only in those cases where severe infection has taken place, or drainage through the middle ear is postponed, that suppurative mastoditis follows an acute infection. A chronic suppuration within the middle ear causes certain changes within the mastoid process, as the result of which the pneumatic structure gradually disappears, and the mastoid becomes sclerotic to a greater or less extent. Instead of these hypertrophic changes, with the deposit of new bone, the opposite result may take place. Bony necrosis may occur, and a large sequestrum may be formed within the mastoid process. If the destruction within the mastoid is but moderate in amount, no sequestrum may be formed, but the detritus may gradually be discharged through the external auditory meatus in the form of pus. Therefore a profuse purulent discharge from the external auditory canal is one of the best signs of involvement of the mastoid process.

The presence of infectious material within the bony cavity may produce several results; the simplest, already mentioned, is a copious otorrhœa. If drainage through the canal is impeded, the fluid must find exit, and evacuates itself spontaneously where the least resistance is offered. This may be—

1. Through the external mastoid cortex, either behind the ear or in the external meatus.
2. Through the cortex in the digastric fossa.
3. Through the root of the zygoma.
4. Through the roof of the antrum, or of the tympanic vault, into the middle cranial fossa.
5. Into the posterior cranial fossa, usually by rupture into the groove lodging the lateral sinus.

When the cranial cavity is invaded we have an inflammation of the meninges, which may be diffuse or circumscribed. In the former condition a purulent leptomeningitis results, while in the latter an epidural abscess is formed. The production of an epidural abscess seems to be an effort on the part of Nature to limit the inflammation to a circumscribed area, the infectious material being walled in on all sides by adhesions between the dura and the adjacent osseous walls. Internal rupture is not the only manner in which the contents of the cranial cavity may be invaded; the free anastomosis between the blood vessels of the dura and the pericranium may furnish the avenue through which the infectious material may pass to the intracranial contents. In this manner we may have, in addition to the two conditions already mentioned, a thrombosis of the lateral sinus, or an abscess within the brain substance. Unfortunately for the patient, these lesions, instead of being single, frequently occur together; thus a sinus thrombosis without considerable meningitis is rare, while a brain abscess is a not infrequent accompaniment of thrombosis of the sinus.

Where rupture takes place upon the external surface of the mastoid, it is commonly supposed that all serious danger of involvement of the intracranial contents is at an end, although the abscess may not be immediately evacuated by incision of the overlying soft parts. This is an error, particularly in the case of children. Here the sutural lines between the various portions of the temporal bone are not completely ossified, and when the external surface of the temporal bone is bathed in pus, infection, either through the sutural lines or through the substance of the squama itself, is by no means impossible.

I have reported one case of this character in a child and one in an adult,* while several other instances may be found in otological literature. In children the presence of pus beneath the integument in the post-aural region does not of necessity indicate a perforation through the cortex. In these young subjects a collection of fluid within the tympanic vault frequently makes its way along the superior wall of the canal, gaining exit from the cavity through the Rivinian segment by dissecting the soft parts away from the bone in this location. In very young infants this is by no means uncommon, while in children over ten years of age it is occasionally met with. Perforation of the cortex on the anterior surface—that is, through the posterior wall of the bony meatus—may occasionally occur. Spontaneous evacuation here is probably due to the fact that in the particular case the external cortex is thicker, while along the posterior aspect of the canal the pneumatic cavities are well developed and thin-walled. Where sequestra are formed the process does not differ, except that in addition to the fluid collection we have a foreign body whose action is to aggravate the changes already described. The same remark applies to the development of a cholesteatomatous mass within the mastoid cells. These epithelial collections are rather prone to excite a hyperplastic inflammation, terminating in sclerosis with obliteration of the trabeculæ between the cells. It is only when the mass attains considerable size that acute inflammatory changes are set up, producing a train of symptoms characteristic of an acute process in this region.

---

* Archives of Otology, vol. xxi, p. 253.

The cholesteatomatous deposit may attain such a size as to cause absorption of the posterior wall of the canal, converting the mastoid, antrum, tympanum, and bony meatus into a single cavity. At the same time the cortex of the mastoid is often sclerosed.

Symptomatology.—The prominent symptom met with is intense pain over the mastoid portion of the temporal bone. The pain is particularly severe at night, preventing sleep. It is of dull character, deep-seated and constant. Following a painful inflammation within the tympanum, a change in the character and location of the pain complained of by the patient is a valuable symptom. The degree of constitutional disturbance presented is often entirely out of proportion to the local changes. The patient may be well nourished, the temperature normal, and the pulse but slightly accelerated, while at the same time extensive destruction is taking place. Where the disease complicates an acute process within the middle ear, or is primary in character, the temperature is usually elevated, varying from 99.5° to 101.5°, but seldom higher than this, except in children where a persistent elevation of temperature may be the only symptom of mastoid involvement. Where the cells are well developed at the apex, considerable difficulty may be experienced in moving the head from side to side. In children this symptom should always be carefully investigated, although no pain may be complained of in the region of the ear. Tenderness upon deep pressure is probably the most characteristic sign of the involvement of the osseous structures. This varies considerably in location. It is usually most marked directly over the antrum and close to the posterior margin of the canal. Occasionally the most tender point will be found at the tip of the apophysis. The aural discharge usually becomes scanty when mastoid symptoms develop. On the other hand, a continuous, profuse discharge is clearly indicative of mastoid involvement. A profuse discharge of long duration could not come from the middle ear alone. In young children who are unable to locate exactly the seat of pain, restlessness at night should always excite suspicion if it follows the cessation of a profuse aural discharge. Tumefaction behind the auricle in not common, except in early life. Œdema of the overlying soft parts is more characteristic of an inflammation within the canal than of involvement of the mastoid process. Fluctuation, it need hardly be said, indicates spontaneous evacuation of the purulent contents.

If the intracranial structures are involved, the symptoms manifested depend upon the particular region attacked. If one of the large venous sinuses becomes the seat of an infectious thrombus, the temperature changes are the most characteristic evidence of the condition. They consist in the sudden elevation of the temperature, the thermometer frequently registering 104° or 105°. This elevation persists but for a few hours, and is followed by a spontaneous fall to the normal standard or even lower than this. These intermittent elevations may occur several times during the day, and may be of such short duration as to be unrecognized unless the temperature is taken frequently. Following the access of the fever there is profuse perspiration, and as the condition advances, well-marked symptoms of general sepsis appear. The patient becomes very weak. The skin is of a dull, ashy hue, the pulse feeble, and the mental condition dull, all of which are indicative of profound systemic infection. If emboli are developed, their lodgment in the various viscera is followed by characteristic symptoms. The most common site of lodgment is probably the lungs, causing a septic pneumonia. When the thrombus develops in the lateral sinus it frequently extends downward into the internal jugular vein, and its presence is revealed by deep tenderness along the course of this vessel, together with tumefaction along the anterior border of the sterno-mastoid muscle. Whenever temperature changes excite suspicion of involvement of the sinus, the region of the external jugular vein should be examined frequently for confirmatory signs. The sensorium is seldom disturbed, except just before death, where thrombosis alone is present.

Where involvement of the intracranial structures results in diffuse meningitis, we have intense headache, photophobia, a high temperature which remains constant, nausea, and vomiting. Otitic meningitis usually involves the base of the brain rather than the convexity. Hence a slow pulse characteristic of traumatic meningeal inflammation is wanting, the

Symptomatology.—This affection is usually accompanied by high temperature, which remains constant, exhibiting but few fluctuations, and varying from 102° to 105°. There is severe headache, photophobia, vomiting, and localized or general convulsions. In children general convulsive symptoms are particularly common, owing to the high temperature. In adults a basilar meningitis does not produce this symptom, but affects groups of muscles supplied by the particular nerves involved at their points of exit from the cranial cavity. These muscular contractions are succeeded by paralysis as the disease advances. When the basilar meninges are affected, the respiratory movements are changed in character quite early, and soon assume the peculiar variety known as "Cheyne-Stokes respiration," in which there are several short efforts at inspiration, followed by a period of complete cessation of the respiratory movements, the lungs being finally emptied by a long sighing expiratory effort. Delirium occurs early in young subjects, but in adult life the sensorium is often not involved until quite late, and delirium may not occur at all, the patient slowly passing into a condition of coma, in which state he dies. The paralyses most frequently met with are those caused by the involvement of the third, fourth, and sixth nerves. An implication of the third nerve causes at first contraction of the pupil, and later dilatation. One of the earliest symptoms of paralysis is failure of the pupil to respond to light, it remaining dilated when exposed to a brilliant source of illumination. The involvement of any of the nerves above mentioned will produce strabismus.

In cases of serous meningitis, both the paralytic and convulsive symptoms are seldom well marked, and are usually entirely absent. In serous meningitis the temperature is rarely as high as in the purulent form; the temperature usually runs from 102° to 103°, seldom higher. Headache is the most prominent symptom of this condition. This may be diffuse or localized. The sensorium is apt to be affected early where the meningitis assumes a serous form. The delirium is frequently of a mild type, the patient being simply restless and answering questions indefinitely, but after his attention is really attracted and an effort is made to secure an answer, the answer will usually be given. Where local paresis occurs, internal strabismus is probably the most frequent symptom. An examination of the fundus oculi will most generally reveal either a choked disk or an incipient swelling of the optic papilla.

In certain cases of middle-ear suppuration, obscure intracranial symptoms intervene which, upon autopsy, are found to be due to a serous meningitis. In these cases, no pus is present, but we have a serous infiltration, either of the meninges or of the brain substance, and in many cases the ventricles are filled with clear serum.

This disease was first brought to the attention of the medical profession by Quincke, as stated on a previous page.

Diagnosis.—The recognition of the affection depends upon the preceding history, associated with constant high temperature, vomiting, and headache. This group of symptoms can be characteristic of no other disease complicating an otitis in adult life. The exclusion of any acute intercurrent affection naturally depends upon the absence of symptoms characteristic of such a disease. In children the diagnosis is much more difficult, since any acute infectious disease or a disturbance of the gastro-intestinal canal will give rise to exactly the symptoms above mentioned.

The cessation of the discharge from the ear coincident with the above manifestations should always render us suspicious of intracranial involvement, while the appearance of tonic spasm of individual muscles, such as those at the nape of the neck, is a valuable confirmatory sign. Photophobia, involvement of the ocular muscles, the interference with the respiratory movements, and subsequently coma, render the diagnosis unmistakable in most cases.

A sign of great value in these cases is the presence of choked disk. In the early stages of meningitis, examination of the optic disks may prove them to be perfectly normal, or the fundus oculi may show a slight engorgement of the veins. If, however, there are any signs of beginning choked disk, such as a haziness and swelling of the margin of the optic papilla or dilatation and tortuosity of the veins, together with some of the symptoms of meningitis already enumerated, the diagnosis is fairly certain. It is, of course, understood that the presence of optic neuritis is not characteristic of meningitis alone. This intraocular condition is frequently found, whenever there is an intracranial lesion of any sort, which increases the intracranial pressure. Hence, we may have a choked disk either in a meningitis, a cerebral or cerebellar abscess, an epidural abscess, a sinus thrombosis, or in cases of intracranial tumor.

Given, however, the presence of optic neuritis and symptoms pointing to meningitis, the presence of optic neuritis tends to confirm the diagnosis. As will be seen from what has gone before in describing the symptoms of serous meningitis, the diagnosis of this condition is exceedingly difficult. A meningitis can usually be assumed to be of a serous form when the temperature is but moderately high, not above 103°, when the headache is not excruciating, photophobia is absent, and where the symptoms develop rapidly, without the characteristic increase in temperature and increase in pulse rate. The pulse in serous meningitis is apt to run slow, owing to the rapid development of pressure symptoms. Rigidity of the neck is a quite frequent symptom in this form of meningitis, although it may be absent.

Prognosis.—Meningeal infection is usually fatal, and yet the results obtained by Macewen,* who reports six recoveries after operation, prove that death does not always follow. In one case of this character, operated on by the author,† the operation was successful.

Treatment.—The application of ice to the head is agreeable, and may retard to some extent the progress of the inflammation. The administration of large doses of bromide of sodium or potassium is also indicated, as it lessens the irritability of the nerve centres. Opiates should be avoided, but may be necessary to relieve the intense pain. Free purgation by means of salines should be resorted to at once. The administration of iodide of potassium internally is permissible, on the assumption of a possible specific taint, either hereditary or acquired. Surgical measures are to be employed, but to be of service must be resorted to early. As the disease will certainly prove fatal if it is not checked by operation, the surgeon should not hesitate to interfere even in cases which are apparently hopeless, if the diagnosis is unquestionable.

SINUS THROMBOSIS.

The occlusion of one of the large venous channels within the cranium by an infectious thrombus is always to be remembered as one of the possible complications of acute or chronic suppuration within the tympanum.

---

* Diseases of the Brain and Spinal Cord, American edition, 1893, p. 329.

† Transactions, American Otological Society, 1896, vol. vi, p. 315.

The free communication through the mastoid veins between the lateral sinus and the pneumatic spaces immediately covering it, renders a suppuration within this cavity particularly prone to deposit septic material within the lateral sinus. Not only may a suppurative process within the mastoid be complicated by this lesion, but a middle-ear suppuration alone, without involvement of the mastoid structures, may cause the condition as well. Here infection usually takes place through the floor of the tympanum, the jugular bulb being directly infected from the middle ear. When such a deposit takes place, the first step of the process is the complete or partial occlusion of the sinus by a clot. The development of pyogenic bacteria within this mass leads to general septic infection, by the entrance of bacteria into the general circulation. The thrombus may remain localized within the sinus itself, affecting but a small area, or it may extend to the internal jugular vein.

General infection may take place through the lateral sinus from periphlebitis, the outer cranial wall, which is deeply grooved for the passage of the vessel, becoming necrotic or carious, and exciting an inflammation of the outer wall of the lateral sinus, lying in immediate contact with it. This is communicated to the interior of the vessel, causing its occlusion in the manner above described. Such a periphlebitis may lead to erosion of the venous trunk before its lumen is occluded by a firm clot, and cause a profuse hæmorrhage.

Provided life is prolonged for a sufficient period to permit of general infection, we find secondary purulent deposits in various organs of the body. The lungs seem to be the favorite site of infection, septic pneumonia being the most common complication.

Secondary brain abscess is also met with, and secondary thrombosis of some of the other venous sinuses within the cranium as well. It is interesting to note that the primary aural affection and the primary sinus thrombosis may cause secondary thromboses and brain abscesses upon the opposite side. For this reason much uncertainty exists as to the ultimate outcome of any operative procedure directed toward the primary seat of affection.

Symptomatology.—The symptoms to which this affection gives rise are insidious in their development, and may escape notice for a considerable period. The symptom characteristic of the involvement of one of the large venous channels is a sudden rise in temperature followed by a spontaneous fall to normal or nearly normal. This may be the only symptom, and, unless the temperature is taken at frequent intervals, may entirely escape observation. The sudden rise in temperature—which is usually excessive, and may reach 104° or 106°—is due to the passage of septic material into the general circulation at successive intervals, owing to the breaking down of the clot within the sinus. After this condition has continued for some time, symptoms of general sepsis develop, such as asthenia, emaciation, and an ashy hue of the skin. The rise in temperature is usually followed by profuse perspiration. In the late stages constitutional depression accompanies this, but when the patient is in fairly vigorous health, as at the onset of the disease, this depression may be so slight as to escape observation. A severe rigor is not an unusual symptom, and is met with in many cases, but is quite frequently wanting. Where it occurs it is of great diagnostic importance, but its absence renders the exclusion of sinus thrombosis by no means certain. Symptoms referable to the cranial contents—such as headache, local or general convulsions, paralysis, mental dullness, or delirium—are absent in uncomplicated cases. Where met with in connection with evidences of sinus thrombosis, we should always suspect the involvement of either the cerebral substance itself or of secondary meningitis affecting a considerable portion of the brain coverings. When there is a secondary process in some remote organ from the lodgment of infectious emboli, we have, in addition to the rise in temperature, symptoms peculiar to the organ involved. As stated above, these deposits occur most frequently in the lungs, and a septic pneumonia is the most common complication. This is of the lobular type, isolated areas of the pulmonary tissue becoming consolidated, and either resolving subsequently or breaking down with the formation of a pulmonary abscess. The liver and spleen may also be the seat of these deposits, but the symptoms presented are so vague as to escape recognition, and the condition is discovered at the necropsy only.

Diagnosis.—The recognition of involvement of the lateral sinus is by no means difficult, as a rule. The sign most characteristic of this condition is the extensive fluctuation in temperature. In order to recognize the condition, it is necessary, therefore, that the temperature be taken frequently. It is wise, in all cases of suppurative otitis media, especially in those where the mastoid has been involved, to have the temperature taken every two or three hours during the day, and at least every four hours during the night. If these frequent observations are not made, the characteristic temperature fluctuations may entirely escape observation, and an error in diagnosis may thus occur. This extensive variation in temperature is in itself sufficient to warrant the surgeon in assuming that the lateral sinus is involved. It should be remembered that sinus thrombosis is not infrequently complicated by a certain amount of meningitis. When this occurs, the temperature will not be intermittent, but remittent, the meningeal inflammation being sufficient to cause a constant temperature elevation of at least one or two degrees above the normal standard. In some cases where septic thrombosis has been present for some time, the thrombus extends downward from the lateral sinus into the internal jugular vein. In these cases there is ordinarily some tenderness in the neck. This tenderness gradually extends downward as the disease advances; at first there is a marked tenderness just behind the ramus of the jaw which slowly extends down to the angle and then farther down the neck along the sterno-mastoid muscle. The superficial and deep lymphatics of the neck are usually involved quite early in the course of the disease. Some writers describe the presence of a hard, cord-like band, to be felt on palpation, along the anterior border of the sterno-mastoid muscle whenever the internal jugular is the seat of a thrombus. I have seen many cases of sinus thrombosis with extension to the internal jugular vein, but in no instance have I ever recognized the presence of this cord-like band occupying the region of the internal jugular. In my own cases, I have often found a brawny swelling just behind the ramus of the jaw, evidently caused by enlarged lymphatics. This sign is, I think, of some diagnostic importance in recognizing the condition under consideration. It must be borne in mind, however, that involvement of the lymphatic glands frequently occurs both in acute external otitis and also in otitis media, without any involvement of the internal jugular vein. Too much importance, therefore, should not be attached to this sign.

An examination of the fundus oculi should always be made in these cases. The presence of a choked disk will confirm the diagnosis of sinus thrombosis in doubtful cases.

Another symptom of diagnostic importance is the development of an asthenic condition without sufficient local disturbance, either in the middle ear or mastoid, to fully account for its occurrence. By exclusion this can only come from general sepsis, and its sudden development is indicative of the conveyance of the septic material into the blood current through a channel of considerable size. The occurrence of rigors and profuse perspiration are of great diagnostic value. The examination of the ear or of the mastoid wound, if an operation has been performed, furnishes practically no information of value. In these cases the importance of the blood culture cannot be overestimated. In any case where sinus thrombosis is suspected, or in fact in any case of middle ear suppuration where unusual excursions in temperature occur, a blood culture should always be made. A positive blood culture is, of course, an absolute evidence that the pathogenic organisms have entered the circulation and constitute an indication for immediate operation. A negative blood culture does not necessarily mean that the lateral sinus is not involved and is not obstructed by clot. Given for instance a case in which a parietal clot is formed in the sinus, a blood culture in such a case should be positive. If, however, a clot forms very rapidly and completely occludes the sinus, a blood culture may be negative simply because the sinus is completely occluded. In a case with a negative culture with occlusion of the sinus this culture will subsequently become positive when the clot breaks down and the pathogenic organisms pass into the general circulation. In one instance I was able to demonstrate this condition; namely, a blood culture from the arm (representing a culture from the general circulation) was negative, but the patient continued to run a temperature characteristic of sinus thrombosis. As the sinus was exposed at the time of operation a culture was taken from the sinus itself, and this was positive. Jugular excision cured this patient.

Prognosis.—A very small proportion of cases of sinus thrombosis may recover spontaneously. In many cases, where spontaneous recovery has apparently taken place, these patients undoubtedly die later from some secondary deposit either in the brain or in some other location. The condition must, therefore, always be regarded as grave, and one which will terminate fatally unless relieved by the surgeon. The results of operative treatment in these cases are exceedingly good. In eighty-eight cases operated upon by the author, sixty-six were cured and twenty-two died: three from septic pneumonia, two from diabetes, two from nephritis, one from meningitis, one from pulmonary thrombosis, one from gangrene of the neck, one from malnutrition, and in the other cases the cause of death was unrecorded.

Where extension to the internal jugular has taken place, the prognosis is naturally more grave than where the disease is recognized before the clot has extended downward. Even where the jugular is involved, however, prompt operative treatment is usually efficient in saving life. Out of fifty-seven cases operated on by the author, a cure resulted in forty.

Pulmonary involvement is not of necessity fatal if the powers of resistance of the patient are sufficient. Death usually occurs either from profound systemic infection, from the development of diffuse meningitis, from the formation of a cerebral abscess, or from extensive pulmonary involvement.

Treatment.—The operative treatment proper in these cases will be discussed in the section devoted to surgery. This, I believe, should always be adopted when the diagnosis is certain. The only therapeutic measures to be employed are those which will most successfully combat the asthenic condition. The free administration of stimulants is indicated, alcohol probably being the best, as it acts both as a food and as a stimulant. When superficial abscesses develop, they are to be opened according to the general rules of surgical practice. The exhibition of large doses of quinine seems to be of value in diminishing the fevrile movement, thus curtailing the excessive tissue waste. Particular attention should be paid to the nutrition of the patient. The systematic administration of milk, eggs, and other highly nutritious and easily digested foods, should be placed in the hands of an experienced nurse, to aid the patient to combat successfully the infectious process. Where the stomach becomes intolerant, the food should be artificially digested before it is administered. Rectal alimentation may be necessary in some cases.

EXTRADURAL ABSCESS.

This condition is essentially one of localized purulent meningitis, in which the *vis medicatrix naturæ* has limited the suppurative process to a smaller area of meningeal surface. In this condition we find the meninges adherent to the internal table of the skull, completely walling in the purulent collection and preventing the development of diffuse inflammation. Most commonly an abscess between the dura mater and the internal table of the skull is a complication of a chronic suppurative process within the middle ear or mastoid. The thin wall separating the lining membrane of the middle ear and mastoid process from the meninges becomes necrotic. During the period in which this process is taking place a localized meningitis of a low grade is developed about the affected area, so that when the necrotic portion separates, the corresponding dural area is completely shut off from the general cranial cavity. This evidently can not occur when the progress of the disease is rapid, the development of organized tissue taking place only after a considerable period of time. A similar localized meningitis may occur from the lodgment of an embolus or from thrombosis of a venous tributary, or often of one of the larger sinuses. For some reason the thrombus does not break down rapidly, but causes a subacute inflammation of the tissues inclosing it, so that when ulceration takes place there is no communication with the general cranial cavity.

Symptomatology.—This condition produces few symptoms characteristic of its presence. The two most important signs are severe and continuous headache, localized over the affected area, a moderately elevated temperature, seldom above 101.5° or 102°, which undergoes slight fluctuations, but seldom reaches the normal standard. Localizing symptoms are rare, no portion of the motor tract being pressed upon.

When situated in the cerebellar fossa, vertigo and vomiting may occur. Mental dullness is met with in the last stages without reference to the location of the abscess, and is probably dependent upon the increase in intracranial pressure from effusion into the ventricles. The chief diagnostic symptoms, however, are the temperature and the headache, which continue in spite of a free opening in the mastoid process. The temperature is not sufficiently elevated to indicate thrombosis or meningitis, this latter being also excluded on account of the mild character of the symptoms, while the absence of any localizing manifestations and the elevation of temperature serve to distinguish it from an abscess in the cerebral substance. The headache is apt to be localized, and over the painful areas the parts are often exquisitely sensitive to pressure.

This sharply localized tenderness is of importance in determining the location of the abscess.

Prognosis.—A collection of pus in this situation may remain latent for a long period. Any acute process involving the middle ear or mastoid may excite it to renewed activity, causing an acute diffuse meningitis or rupture of the abscess, with evacuation into either the cranial cavity or cerebral substance. Death may be caused by the increased pressure if the rupture is intracranial, or external rupture occasionally takes place, with abatement of the symptoms. When the abscess is recognized and evacuated, recovery is the rule. Out of twenty-five cases operated upon by the author, twenty-three recovered and two died. Spontaneous evacuation through the outer wall of the cranium, with subsequent favorable progress, has occurred in two cases observed by Knapp. The abscesses opened near the occipital protuberance in both cases.

Treatment.—Internal medication should be limited to the administration of supporting and stimulating agents. The only curative measure is the evacuation of the abscess, the technique of which procedure will be described later.

CEREBRAL ABSCESS.

A localized purulent focus within the brain tissue may be either acute or chronic in its development. The acute cases are rare, while it is probable that the most common cause of chronic cerebral abscess is a purulent otitis. These abscesses may be single or multiple; they may involve the cortex or the deeper regions of the brain, and may be limited to one side, or may be met with in both cerebral hemispheres. They may follow either a simple inflammation within the tympanum, with the formation of pus, or a similar condition within the mastoid, an infectious thrombosis, or an epidural purulent collection. From my personal experience, the temporosphenoidal lobe is the region most frequently involved, although Körner* finds the cerebellum more frequently involved than the cerebrum. Out of 100 cases, collated by the author,† infection occurred through the tegmen tympani in forty, by way of the lateral sinus in six, secondary to epidural abscess in six, through the mastoid antrum in six, secondary to infection through the squama in two, secondary to cerebellar abscess in one, and in nine no bone defect was found. The route of infection is not stated in the other cases.

---

* Otitischen Erkrankungen des Hirns, der Hirnhäute und der Blutleiter, p. 6.

† American Journal of the Medical Sciences, November, 1907.

As a rule, they are situated rather deeply in the cerebral substance, and if left to themselves may rupture into the lateral ventricles. Discharge of the contents through the meninges occasionally occurs where the accumulation is superficial, and in rare instances the pus finds its way through a perforation in the tympanic roof, and appears externally as a discharge from the meatus. An abscess may remain latent for a period of many years, being excited to renewed activity by the occurrence of an acute inflammation of the region primarily involved.

Examination of many of these abscesses shows that the contents are sterile, artificial cultures being entirely inert.

Symptomatology.—The most prominent symptom of a cerebral abscess is undoubtedly headache. This symptom was prominent in seventy-seven out of 100 cases collated by the author.* Vomiting is a very important symptom, and was present in forty-four of the above cases. The pulse was slow in thirty-seven cases, and rapid in one case. Mental dullness is a prominent symptom, and should attract attention. Convulsive seizures may occur if the motor tract is involved, although these seldom appear. Paralytic or paretic symptoms are more common, although these are relatively rare.

The favorite site for the development of this abscess is in the temporo-sphenoidal lobe, and hence characteristic localizing symptoms are only produced when the abscess has attained considerable size, in which case it involves the speech area, and produces either sensory or motor aphasia. The aphasia in these cases is sometimes only recognizable upon a rather careful examination. The patient may be able to answer questions perfectly, but on being asked the names of various objects presented to him, will hesitate and respond slowly, or may name the article wrongly. This, of course, indicates involvement of that portion of the brain through which the fibres running from the visual centre to the word centre pass. In many of these cases, if the object presented to the patient is named, he is able to repeat the name; for instance, if a key is shown the patient, he may be unable to say the word "key," yet will repeat it after the examiner or may say it is for unlocking the door, designating the use of the article, but entirely forgetting its actual name. It goes without saying that the aphasic symptoms are only present where the abscess is located upon the left side.

---

* Transactions of the American Otological Society, 1907, p. 486.

The symptom of agraphia is also present in some of these cases. As the great majority of the patients suffering from severe intracranial complications are met with in hospital practice, this manifestation is not as important a diagnostic feature as is that of aphasia, many of these patients not being able to write at all or at the best writing very poorly.

Sometimes localizing symptoms are wanting; this is especially true if the abscess is situated upon the right side, in which case the speech centres would not be involved. The asthenic condition is more indicative of the affection than is any special manifestation. From a rapid increase in the size of the abscess, local or general convulsions may occur; the pulse may be accelerated in acute cases, the relation between the pulse and the temperature being the same as that characteristic of meningitis. In the chronic cases development is so insidious that the first symptom noticed is a condition of marked physical impairment. The mental status furnishes valuable information as well, the patient being irritable at times, while at other times, he is either inattentive or even somnolent. This condition of hebetude gradually deepens to one of coma. The temperature is seldom elevated above 99°; the pulse is usually slow, occasionally intermittent. Headache of a dull, diffuse character is complained of in cases of long standing. Sometimes sleeplessness is the only symptom for which the patient seeks advice.

The termination of the case is usually sudden, death taking place from rupture into the ventricles or from compression or destruction of the vital centres.

Diagnosis.—The recognition of the presence of a cerebral abscess is exceedingly difficult. The persistent headache, slow pulse, vomiting, mental dullness, which is gradually progressive, are all significant of the presence of pus within the brain. Localizing symptoms, if present, naturally render the diagnosis easy. In addition to these symptoms, the gradual impairment of the general condition of the patient from no assignable cause, is a sign which should always be borne in mind.

was present in about 50 per cent, and this symptom should always be looked upon with suspicion. Vertigo is a symptom of considerable moment, and was noted in 30 per cent of the series of cases collated. Nystagmus is a symptom of importance. The nystagmus is usually toward the affected side. Nystagmus toward the affected side, with failure to react to the caloric test, is a very significant symptom of cerebellar abscess. The pulse is usually slow in these cases, owing to the increased intracranial pressure. In three of the cases which have come under my observation, the patients have died suddenly and undoubtedly from rupture of the abscess into the fourth ventricle, and the condition was discovered only upon autopsy. In one of these cases, persistent headache was complained of. The temperature in these cases may be somewhat elevated, although it is seldom high until just before a fatal termination. In three cases which have recently come under observation, the temperature did not go above 101° until twenty-four hours prior to the time of death. Two of these cases had a sudden and inexplainable rise of temperature, followed by general convulsions, coma, and death. In the third case the coma supervened immediately after operation. A brain abscess had been suspected at the time of operation, which consisted simply in the radical procedure for the relief of a longstanding purulent otitis. The cerebellar abscess was discovered after death.

It will be seen from the history of these cases, and from many others reported in literature, that the symptoms of this condition are most obscure. Where such symptoms as vomiting, unsteadiness in gait or nystagmus are present in any case suffering with an aural discharge which has lasted for some weeks, the possibility of cerebellar involvement should always be borne in mind.

Diagnosis.—The recognition of this condition presents many difficulties. I think we may say that, as a general rule, a cerebellar abscess will only be recognized upon the operating table. It may be suspected if the symptoms characteristic of this condition, and noted in the previous paragraph on Symptomatology, are present. As these are very frequently absent, however, the surgeon will probably simply make the diagnosis that the patient is suffering from some intracranial lesion of otitic origin, and the presence of the cerebellar abscess will be discovered upon an exploratory craniotomy. An examination of the fundus oculi will, in many of these cases, reveal the presence of a choked disk. The surgeon will consider the cerebellum the probable site of the lesion, when the symptoms point to an intracranial collection of pus, and the localizing symptoms characteristic of either cerebral abscess or basilar meningitis are absent. It should be remembered that a cerebellar abscess not infrequently causes an acute dilatation of the lateral ventricles, and that the symptoms may be simply those of serous meningitis. Dilatation of the ventricles may be found at the time of the exploratory operation, and, under these conditions, it is always wise to explore the cerebellum, in order to find a possible cause for this ventricular effusion.

Prognosis.—As the condition is so difficult of recognition, the prognosis is naturally unfavorable. If the disease can be recognized and the pus evacuated, the patient has a fairly good chance of recovery. Macewen* reports four cases operated upon by himself, all of which recovered.

Körner† reports twenty-nine recoveries out of fifty-five collated cases operated upon.

Out of one hundred and two cases of cerebellar abscess, collated by the author,‡ sixty-nine died and thirty-three recovered.

Treatment.—As in the case of cerebral abscess, the only hope of recovery lies in operative treatment. The technique will be described later. It is interesting to note that in the cases collated by the author§ that in forty-five cases the abscess was opened behind the lateral sinus; twenty-five cases were cured and twenty died. In eleven cases the abscess was opened in front of the sinus; four recovered and seven died. In forty-six cases the method of operation was not stated; four cases recovered and forty-two died.

---

* Pyogenic and Infective Diseases of the Brain and Spinal Cord, New York, 1893, p. 333.

† Die otitischen Erkrankungen des Hirns, der Hirnhaute und der Blutleiter, p. 191, Wiesbaden.

‡ *Loc. cit.*

§ *Loc. cit.*

SECTION III.

SURGERY OF THE CONDUCTING APPARATUS.

SURGERY OF THE CONDUCTING APPARATUS.

UNDER this section we shall consider those procedures demanded by various pathological conditions affecting this portion of the body. While the term embraces all operations upon the auricle, canal, tympanum, mastoid, and adjacent regions, it is evident that many of these belong more to the domain of general than of special surgery. In this section we shall confine ourselves to those operations which are not considered in detail in works on general surgery and which are of interest to those engaged in special work.

For this reason operations for the removal of neoplasms of the auricle or for the correction of deformities of the external ear will not be described. On the other hand, the frequent occurrence of intracranial complications as the result of aural suppuration renders the consideration of the proper treatment of such affections imperative.

CHAPTER XXVII.

MIDDLE-EAR OPERATIONS.

PREPARATIONS PRELIMINARY TO OPERATIONS UPON THE TYMPANIC CAVITY.

Instruments.—Every operator will from habit develop a preference for some particular form of instrument which in his hands will be more valuable than one of another pattern. Emphasis should be laid upon the fact that in this branch of surgery, as in all its branches, the object to be attained should be kept in mind rather than the particular appliance with which it is to be effected. In a general way the operator a number of years I have employed with great success a series of instruments the blades of which are forged from small steel wire of the correct size (Fig. 123). The shaft of each instrument is provided with a screw thread which enables it to be fastened firmly into a small handle made of octagonal brass rod. The shank of the knife is left malleable, which permits of its being bent at an angle with the handle, or being used as a straight instrument, according to circumstances. These instruments are comparatively cheap, and this is a matter of considerable consequence, as the instruments become useless after a few operations. It is important that all knives should possess sufficient thickness at the back to permit the blades to be honed to a keen edge. No cutting instrument which is thin and spatula-like can be brought to a fine edge, no matter how much care is exercised. Too much stress can not be laid upon the necessity of having all cutting instruments as sharp as care and art can make them. It may seem superfluous to lay much stress upon this point, but it is so commonly neglected in aural surgery that I feel warranted in emphasizing it here.

Concerning the preparation of the instruments for operation, immersion in a boiling soda solution of the strength of one per cent has in all cases proved satisfactory. The larger instruments, such as forceps, probes, specula, etc., may be allowed to remain in the boiling solution for from three to five minutes. Delicate knives, however, should be simply immersed for a moment and then withdrawn.

Preparation of the Field of Operation.—Where there has been no discharge from the external auditory meatus it usually suffices to cleanse thoroughly the ear at the time of the operation by means of a solution of bichloride of mercury of the strength of 1 to 3,000 in equal parts of alcohol and water, the lotion being applied by means of a cotton-tipped probe. The walls of the canal should be thoroughly scrubbed so as to remove not only any superficial deposit which may be present, but also any desquamated epithelium which may adhere closely. It is better, however, to precede this cleansing by having the ear syringed once daily upon the two days preceding the operation with an aqueous solution of the bichloride of mercury of the strength of 1 to 5,000, the canal being occluded by a pledget of sterilized cotton immediately after the irrigation and the pledget allowed to remain *in situ* until the next cleansing. It is a fact not ordinarily recognized that low vegetable organisms, such as various forms of aspergillus, are encountered quite frequently in the external auditory meatus, and in no small degree tend to excite inflammatory action after operative procedures; and it is for the purpose of thoroughly eradicating these growths from the field of operation that the above measures are advised, even in cases where the canal seems perfectly clean. Where there has been an otorrhœa of long standing it is still more necessary to cleanse the parts thoroughly by irrigation with antiseptic lotions before resorting to any operation. Thorough syringing, either once or several times daily, according to the amount of discharge, is imperative for at least five days before any operative procedures are attempted. The particular antiseptic chosen is a matter of little importance; the bichloride-of-mercury solution of the strength of 1 to 5,000, or a dilute solution of peroxide of hydrogen, or of carbolic acid 1 to 50, or a saturated solution of boric acid, are all fairly efficient. Either a few hours before the operation or immediately preceding it the field should be cleansed with the alcoholic solution in the manner mentioned before.

Where proper attention has not been paid to cleanliness, we frequently find in old cases of otorrhœa that the tympanum is filled with exuberant granulations due to the effect of heat and moisture, as well as to the presence of necrosed bone. Cleansing will do much to reduce these efflorescent masses, but it may be necessary to curette thoroughly the entire cavity before any further operative measure is employed, in order that the extreme vascularity of the parts may not interfere with a delicate operation in such a limited field. Where evulsion is not indicated the actual or chemical cautery may reduce the granulations sufficiently.

Anæsthesia.—Where the membrana tympani is present it is usually possible to perform the various operations upon the middle ear under local anæsthesia, provided the patient possesses a fair amount of self-control. When the membrana tympani is to be incised for the relief of an acute inflammatory process of the middle ear, the procedure is rendered entirely painless by nitrous oxide anæsthesia. In operations having for their object an improvement of the hearing it is particularly advantageous that the patient shall retain consciousness throughout, in order that the results of the various steps may be closely noted. The primary incision through the membrane is the only step attended with pain, and this is insignificant where the knife is in a proper condition. Absolute anæsthesia is obtained subsequently by touching the edges of the incision with a cotton-tipped probe moistened with a ten-per-cent solution of cocaine, the probe being subsequently introduced into the tympanic cavity to anæsthetize its lining membrane. As the local application of cocaine to the middle ear may be followed by unpleasant constitutional effects in certain cases, it is often wise to use first cocaine, and then a two-per-cent solution of eucaine (B). The only disadvantage of the latter drug is that it causes considerable hyperæmia. Alypin may also be used in cases where cocaine is known to produce constitutional symptoms. Bleeding is sometimes annoying, in that it prevents the surgeon from viewing the operative field thoroughly, and here the use of a sterilized solution of adrenalin chloride, of a strength of 1-3,000, is of great value. This solution is applied to the middle ear through the incision in the drum membrane, by means of a cotton-tipped probe.

The Position of the Patient.—Since we are accustomed to inspect the ear with the patient either in an erect or semi-recumbent posture, it is somewhat inconvenient to operate with the subject in the horizontal position. If a general anæsthetic is necessary the upright position is not available, but here it is always advisable to operate with the shoulders elevated so that the head can easily be turned in any direction. The rest shown in Fig. 124 will be found convenient in securing this end if a suitable operating chair or table is not at hand.

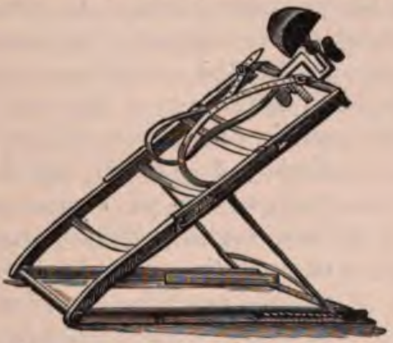


FIG. 124.—Author's head and shoulder rest.

CLASSIFICATION OF OPERATIONS.

The various intratympanic operations may be classified as follows:

I. *Operations involving the Membrana Tympani alone*, comprising, (*a*) Perforation of the membrane (myringotomy). (*b*) Removal or destruction of a segment of the membrane to establish a permanent opening (partial myringectomy). (*c*) Single or multiple incision of the membrana tympani to correct anomalies of tension. (We include here section of the posterior fold, or plicotomy.)

II. *Operations involving the Intratympanic Soft Parts.*—(*a*) Tenotomy of the tensor tympani muscle. (*b*) Section of the anterior ligament of the malleus. (*c*) Section of adhesions resulting from suppurative or nonsuppurative inflammation.

III. *Operations involving the Ossicular Chain.*—(*a*) Excision of a portion of the malleus. (*b*) Disarticulation at the incudostapedial joint, or division of the long arm of the incus, with mobilization of the stapes. (*c*) Plastic operations for uniting either the stapes or the incus to the membrana tympani directly. (*d*) Excision of individual ossicles, or of the entire ossicular chain.

I. OPERATIONS INVOLVING THE MEMBRANA TYMPANI ALONE.

(*a*) *Myringotomy.*—A simple incision through the drum membrane may be performed either to evacuate fluid, to deplete the parts, or for the purpose of exploration. Formerly the drum membrane was considered so important a structure that interference with it was seldom deemed justifiable. Too much can not be said for the purpose of correcting this error. Granting that the instruments, the field of operation, and the operator are aseptic, an extensive incision through the structure, even in a state of health, will be followed by no untoward consequences. The linear wound will heal completely within twenty-four hours and the function of the organ will in no way be interfered with. For whatever purpose the procedure is employed, it should always be remembered that the incision should be free rather than limited in extent. Formerly, for the evacuation of fluid within the tympanum it was the custom to "puncture" the drum membrane with a small lance-shaped knife (Fig. 125). The failure to secure speedy convalescence was then attributed to the operation. At the present day, when we wish to evacuate fluid from the tympanum, the parts are freely incised and the cavity emptied, and at the same time the vascular turgescence is relieved, so that the cut edges approximate closely and unite at the end of a few hours.

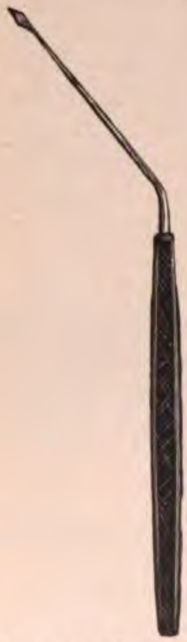


FIG. 125.—Myringotome.

Operation.—The field of operation and the instruments being thoroughly aseptic, the surgeon exposes the fundus of the canal by the insertion of a speculum of the proper size. The site of election for perforating the drum membrane varies according to the manifestations in each particular case. If fluid is to be evacuated our incision should commence at the most prominent point and should extend either upward or downward through the bulging portion. Section is most effective by using the sharp knife shown in Fig. 123, *e*. If the bulging involves chiefly the upper part of the drum membrane the knife should be carried into the canal with the cutting edge upward. Its point is entered at the apex of the tumefaction and carried rapidly through the drum until it impinges upon the internal tympanic wall, after which it is made to cut upward toward the periphery as far as may seem necessary (Fig. 97). As the most prominent region is almost invariably in the posterior quadrant, and usually in the postero-superior, care must be taken to avoid striking the long portion of the incus with the point of the knife. When the primary incision is made the malleus shaft can usually be sufficiently well made out to be avoided; but if the knife impinges upon this the operator will have failed to secure a proper opening, the resistance being firm and the knife seldom gliding off so as to pass through the membrane and evacuate the contents of the cavity. To avoid injuring the incus and stapes it is necessary that the operator should hold the instrument delicately between the thumb and finger in making the upward stroke, when contact with these structures will be immediately recognized, and the blade may be slightly turned so as to avoid them. Where the most prominent area corresponds to the lower half of the tympanic cavity incision in the opposite direction is usually more convenient. In this case the knife is introduced in the canal with the cutting edge downward. Here no important structures can be encountered and the procedure is relatively simple. It is usually wise to make this incision somewhat curvilinear, following the peripheral attachment of the membrane, the incision passing close to the cartilaginous ring. Approximation is more perfect when the wound is located here and cicatrization correspondingly more rapid. In all cases attended with congestion or an inflammatory process the inner tympanic wall should be incised at the same time to secure local depletion. Regarding the absolute extent of the incision, it is seldom wise that this should be shorter than one half of the long diameter of the membrane if lying in a vertical direction, or less than one fourth of the periphery if located near this.

It is well to remember that the plane of the membrana tympani is obliquely placed to both the horizontal and vertical transverse planes of the body. An instrument introduced into the meatus and carried horizontally inward will frequently not pass through the drum membrane, but will be deflected from its surface and inflict but a superficial wound. This is particularly true when the bulging involves the superior segment, and in children. In order to enter the tympanic cavity the knife must be passed not only inward, but inward and upward, and even after the point has passed through the membrane the handle should be strongly depressed, so as to carry the blade well up into the cavity. In an infant the plane of the membrane is nearly horizontal, and unless particular attention is given to this fact the operation will be inefficiently performed. It is well in operating upon a young child, and even upon an adult where the canal is narrow, to employ a curved knife (Fig. 87) rather than a straight one, as an extensive incision is more easily made if this is done.

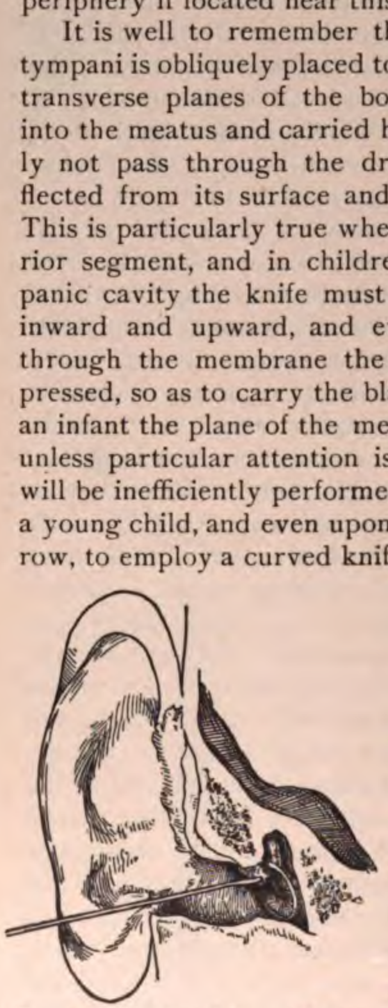


FIG. 126.—Incision of Shrapnell's membrane in the early stages of acute purulent otitis. (The continuation of the incision upon the superior wall of the canal is indicated by the dotted line.)

Where myringotomy is performed for depletion alone in those cases where the acute inflammatory process has begun in the vault of the tympanum, the atrium remaining free, our success in aborting the attack will depend largely upon the thoroughness with which we divide the connective-tissue structures lying in the tympanic vault. In such a case the knife should be introduced with the blade lying in the horizontal plane, the cutting edge looking backward (Fig. 126). The point punctures the drum membrane just above and behind the short process of the malleus, the knife being passed upward and inward and a little backward, to avoid the body of the incus. The incision is then carried horizontally backward to the periphery, when the cutting edge of the knife is turned upward and the incision extended for a short distance along the superior wall of the canal (as shown by the dotted line in Fig. 126). This severs the numerous reduplications of mucous membrane and efficiently depletes this region and the lining membrane of the mastoid antrum.

Exploratory Myringotomy.—When it seems desirable to explore the interior of the tympanum, the end is most easily attained by reflecting a flap of the membrana tympani. As the region demanding particular inspection is that occupied by the incudo-stapedial articulation and the niches of the oval and round windows, the field of operation lies in the posterior segment. This has been proved to be the part possessing the least tactile sensibility, and primary incision, if located just within the clear membrane close to its posterior border and midway along the periphery, can be made with scarcely any pain. The knife should possess so keen an edge and so sharp a point that it will penetrate the delicate septum by its own weight. The puncture should be made within the clear membrane to avoid hæmorrhage, and especial care is to be taken that the mucous membrane over the internal wall is not wounded, for the same reason. After a short incision has been made in this region a ten-per-cent solution of cocaine is applied to its margins by means of a cotton-tipped probe, after which the section is carried upward along the peripheral attachment to the posterior fold, then forward just below this to the short process of the malleus, where it again turns downward and runs parallel with the manubrium and posterior to it (Fig. 127). It is usually necessary to repeat the process of anæsthetizing several times before the incision is completed, but if this is carefully done not the slightest pain is experienced. The flap now falls outward and the tympanic cavity lies open to inspection (Fig. 136). In the great majority of cases the in-

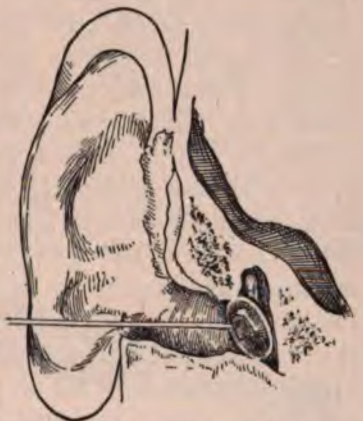


FIG. 127.—Exploratory myringotomy.

cudo-stapedial articulation will readily be seen, and the degree of mobility of the stapes and the amount of motion possible at the malleo-incudal joint can be determined by manipulation with a cotton-tipped probe or by passing a delicate hook behind the descending arm of the incus. If the round window is not exposed, or if the flap does not turn readily, the original incision may be extended downward along the posterior peripheral margin as far as the inferior pole. Displacement of the flap may not expose the incudo-stapedial articulation and the niche of the round window in some cases, as these may be covered by the fold of the posterior pocket or by certain irregular reduplications of the mucous membrane. These folds may be so delicate that they are recognized with difficulty and yet hide completely the landmarks within the tympanum. If the various landmarks are not seen upon reflection of the flap, the sharp-pointed knife should be used to make one or two short vertical incisions through the membrane over the inner tympanic wall. The edges of the incisions separate, from the elasticity of the membrane, and the landmarks appear. The cavity having been explored and the indicated measures adopted, the flap may be replaced and held in position by a bit of thin sized paper which has been previously soaked in a solution of bichloride of mercury (1 to 3,000). This paper dressing is introduced into the meatus either on the end of a cotton-tipped probe or by means of a forceps, and is placed upon the surface of the drum membrane, and by manipulation made to slide over this until the flap is replaced, when further manipulation carries the paper disc over the line of incision, sealing it and retaining the edges in position by its adhesion to the surrounding intact surface. At the end of one or two days the healing process is complete, and the paper is subsequently thrown out by the outward growth of the epithelial layer of the membrana tympani.

(*b*) *Partial Myringectomy.*—It is seldom possible, by the excision of any portion of the membrana tympani or by destruction by caustic agents, to secure a permanent opening through the drum membrane. When we desire to determine what the effect of a permanent opening would be in any given case, a partial myringectomy will enable us to attain this end, although the opening will usually close at some subsequent period.

The operative technique consists in the excision of a flap which is to be formed in the manner already described in exploratory myringotomy. If caustic agents are to be used, a minute drop of the concentrated sulphuric acid is applied, by means of a cotton-tipped probe, to the area chosen for perforation, care being taken that no acid in excess of what is required to saturate the cotton, is conveyed into the canal. The instrument is carried rapidly through the canal and pressed against the membrane for a few seconds, causing a rapid necrosis of all the layers, the affected portion becoming of a dead-white color. The probe easily breaks down this necrotic tissue and enters the tympanic cavity. There is but slight pain, and if care is taken to use but little acid there is seldom any reaction. The galvano-cautery may be employed in the same manner. Comparing these three methods, excision is undoubtedly the safest plan, but it is the most difficult to accomplish, the removal of the small flap being by no means easy. The small scissors shown in Fig. 128 will be found useful in separating the flap when it is attached by a narrow pedicle only. When the flap can not be excised, it may be folded upon the outer surface of the membrane, the pedicle by which it is attached being made as narrow as possible. Unless the flap is replaced, the opening will remain patent for from two to six weeks, during which time the conditions are much more favorable for observation than where resort has been had to undue violence completely to excise the flap, or where the parts have been irritated by either an escharotic or the actual cautery.

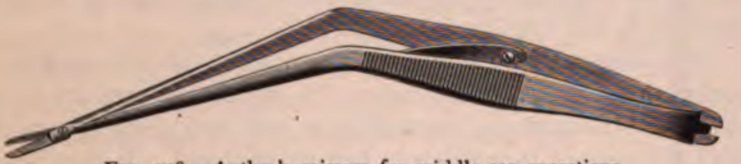


FIG. 128.—Author's scissors for middle-ear operations.

(*c*) *Multiple Incision of the Membrana Tympani.*—Politzer * and Gruber † both propose this operation, but for exactly opposite conditions, the former advising it where the membrana is much relaxed as the result of the cicatrization of a larger perforation, while the latter employs it to relieve increased tension, the result of an inflammatory process. Gruber advises that several incisions be made from the centre of the membrane toward the periphery, through the dense areas, the adjacent incisions being connected by tranverse cuts, the lines of section forming the letter H. Where it seems advisable to employ the procedure for a relaxed condition, it is necessary only to divide the cicatrix completely, or in some cases to excise a portion of it. It would be exceptional to find any permanent benefit from this operation, since the newly formed cicatrix must soon become relaxed.

---

* Wien. med. Woch., 1871, p. 9. † Allg. Wien. med. Ztg., 1873, p. 2.

Plicotomy.—The posterior fold of the membrana tympani may be divided for the relaxation of tension, either in the direction of or at right angles to its long axis. When it is to be divided transversely the point of the knife is entered just above the posterior fold, midway between its posterior extremity and the short process of the malleus. After piercing the membrane a quick downward stroke severs the tense band. In order that immediate reunion shall not take place Politzerization or inflation by means of the catheter should be practiced daily for four or five days.

The longitudinal section of the fold needs no special description. The knife punctures the membrane just below the fold near the anterior or posterior end and divides horizontally the tissues immediately below the band. It thus severs any radiating fibres and relaxes the tension.

II. OPERATIONS IN WHICH THE VARIOUS MUSCULAR OR FIBROUS STRUCTURES WITHIN THE TYMPANUM ARE DIVIDED.

(*a*) *Tenotomy of the Tensor Tympani Muscle.*—This procedure was proposed by Hyrtl,* although F. E. Weber† was the first to perform it upon the living subject. The indications for its performance have been sufficiently stated in an earlier portion of the volume.

Since in a sclerotic condition of the mucous membrane of the middle ear tactile sensibility is much diminished, it is usually stated that general anæsthesia has seldom been necessary for the performance of the operation. My own experience has been, however, that it is less readily carried out than some of the more complicated procedures within the tympanic cavity, and I believe that in order to be successfully performed general anæsthesia should be induced in most cases.

---

* Topographische Anatomie.

† Berlin. klin. Woch., 1871, p. 574.

There are several methods of severing the band. Weber-Liel, and Cholewa make use of a knife of special construction for dividing the tendon. In this instrument the blade is hook-shaped and the shaft of the knife is fixed in an angular handle so arranged that the knife can be rotated upon its long axis by the manipulation of a slide on the side of the handle. The technique is as follows: The membrana tympani is incised in front of the processus brevis, the hook-shaped knife introduced into the cavity, and by depressing the handle and carrying it somewhat forward the blade is made to press upon and partially encircle the tendon; by rotating the blade the tendon is severed. To remove the knife the blade is rotated to its former position by reversing the manipulation. Forcible inflation by Politzer's method or with the catheter, and the insufflation of a little boric acid into the canal, completes the operation. Most commonly the procedure is conducted without resort to so complicated an instrument as the one described, and most operators prefer to enter the tympanic cavity behind the malleus handle. Gruber* advises that the tenotome be introduced through the membrane in either the anterior or posterior segment, according to their relative accessibility. Schwartze, Pomeroy, and Green employ a blunt-pointed knife curved on the flat. Hartmann has devised an instrument (Fig. 129) which is curved both on the flat and in its long axis, the blade being sharp-pointed, so that when the middle ear is entered the sharp point of the knife can be carried high up into the tympanic cavity The position of the puncture and the manipulation of the instrument after the blade has entered the tympanic cavity will vary according as the tendon is to be divided from above downward or from below upward. Here again the operator is allowed considerable latitude. The technique depends upon the conformation in each individual case. If

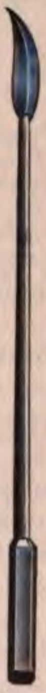


FIG. 129.—Hartmann's tenotome (slightly enlarged).

---

* Lehrbuch für Ohrenheilkunde, Wien, 1888, p. 562.

the tendon is to be divided from above downward the membrane is punctured immediately behind the short process, and the curved or angular blade is carried high up into the cavity by depressing the proximal end of the instrument, which at the same time is carried a little backward, causing the blade to apply itself closely to the manubrium. The blade is then rotated forward and downward through an angle of ninety degrees, and section is accomplished by a slight sawing motion, downward pressure being exerted during the withdrawal of the instrument. As the tendon is severed the operator feels the resistance which it offered suddenly overcome, and a sharp click is frequently heard at this moment. To divide the tendon from below upward the membrana is punctured just below and behind the short process. Upon entering the cavity the instrument is advanced forward, inward, and downward, the shaft remaining almost horizontal, and the flat surface of the blade closely applied to the handle of the malleus until it has traversed the breadth of the cavity. The handle is then depressed, thus carrying the curved point of the knife high up in the tympanum. The instrument is then withdrawn, upward pressure being continually exerted and the tendon divided from below upward. The technique described presupposes the use of

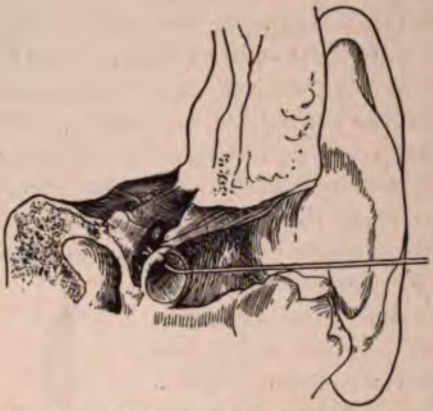


FIG. 130.—Tenotomy of the tensor tympani. The knife is shown above the tendon, which is divided from above downward.

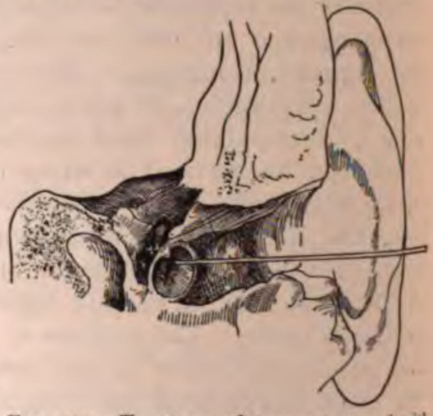


FIG. 131.—Tenotomy of tensor tympani with Hartmann's knife.

Hartmann's tenotome, which, being sharp-pointed, is used both to puncture the membrane and to sever the tendon (Fig. 131.) When a blunt-pointed knife curved on the flat is used, the drum membrane is incised close to and behind the handle of the malleus with a sharp knife; through this opening the curved knife is inserted, its concavity being directed toward the manubrium. The tendon is divided by depressing the handle of the knife and extending the incision upward toward the short process (Fig. 132.) When it seems desirable to divide the tendon through an incision in the anterior segment, the curved knife enters the cavity somewhat below the short process. It is then advanced upward and backward, the flat surface of the blade passing closely along the manubrium and severing the tendon as the incision is extended. Where tenotomy is deemed advisable in cases of residual purulent inflammation, a large perforation being present, no preliminary incision is necessary, the knife being introduced through the existing perforation; the tendon is severed either from below upward, or in the reverse direction, according to the special topography of the case.

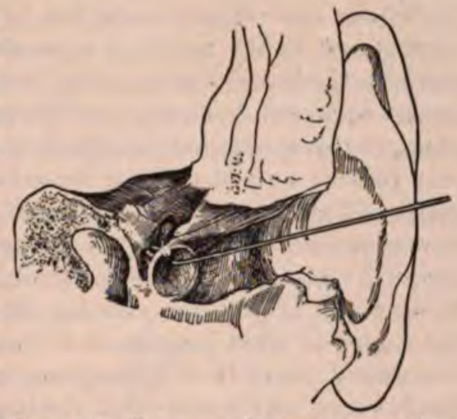


FIG. 132.—Tenotomy of tensor tympani from below upward.

(*b*) *Division of the Anterior Ligament of the Malleus.*—This measure was advocated by Politzer * in cases of marked retraction of the membrana tympani, it being found in several instances that tenotomy of the tensor tympani alone did not allow the parts to resume their normal position, although this was possible if the anterior ligament had been severed.

The membrane is punctured just in front of the short process with a short curved knife, with the cutting edge directed upward. The knife is carried inward almost to the bony wall, when the handle is depressed, crowding the edge against the ligamentous tissue in the anterior fold, which is divided as the knife is withdrawn.

---

* Diseases of the Ear, Am. edition, Philadelphia, 1883, p. 379.

(*c*) *The Division of Adhesions, the Result of Suppurative or Nonsuppurative Inflammation.*—We may divide these adhesions according to their location into two classes:

1. Adhesions about the stapes itself.
2. Adhesions between the malleus and incus and inner tympanic wall, or tense bands immobilizing the entire ossicular chain, the articulations between the various ossicles being intact.

When the rigidity depends upon adhesions about the stapes itself as the result of a purulent otitis, the incudo-stapedial articulation having been destroyed, we find the pelvis ovalis occupied by a mass of dense tissue which frequently changes the appearance completely. The head of the stapes may present only as a slight elevation upon the surface of the mass. Close inspection may reveal a preponderance of the newly formed tissue along the posterior margin of the pelvis, especially about the stapedius tendon, which can occasionally be seen as a bright line running through the mass. To see the stapes or what remains of it I usually first incise directly downward close to the tympanic ring, so as to divide any bands which may tend to pull the stapes out of the visual field. To effect this the knife is to be carried inward just above the fibrous band which we wish to divide, and close to the tympanic ring, until its point impinges upon the bony inner wall of the tympanum (Fig. 134.) It is then carried downward, the point being still kept against the inner wall, and severs the tendon of the stapedius. together with all adhesions which passed from the ossicle toward the posterior tympanic wall. This relieves the stapes from the pull of the stapedius muscle, and from the tension of the adhesions which have developed in front, it comes more clearly into view. Care should be taken in passing the knife inward not to carry it too far, in case the bony resistance is not felt at the proper depth, for fear of its entering the vestibule and injuring the labyrinth. After the posterior bands have been severed, short radiating incisions are made, taking the oval window as a centre from which they diverge. This allows the parts to retract, and by local depletion favors the formation of a thin cicatrix, in place of the thick fibrous deposit. The operation is completed by the insufflation of a little boric acid. It may be necessary to repeat this procedure several times before the desired result is obtained, since during cicatrization other adhesions may form. Careful attention will enable the surgeon to overcome the rigidity permanently in a large number of cases.

In the second class of cases, where the entire conducting chain is bound down, relaxation of tension is frequently obtainable by surgical interference. In many cases a large perforation is found, in the lower half of the membrane, the margins of the perforation may adhere to the internal wall of the middle ear throughout; or this condition may be confined to the region of the tip of the malleus handle. In these last cases the blunt knife, curved on the flat, should be used to divide the fibrous bands, or in some cases vertical incisions may be made through the cicatrix, or the point of adhesion may be taken as a centre from which these incisions shall radiate.

Another condition, not uncommon, is where a considerable portion of the membrane is destroyed, the remnant of the membrane in the upper and posterior quadrant being thickened and tense, so that its lower border, corresponding to the posterior fold, forms a dense fibrous band, crowding the underlying structures firmly together, and sometimes partially hiding the stapes or incudo-stapedial articulation from view. Section of this band, by an upward incision (Fig. 133), frequently improves the hearing; or the procedure may be advisable as an exploratory measure, the retraction of the cut edges permitting an inspection of the structures lying in the pelvis ovalis, and revealing a condition here which may be amenable to operative treatment.

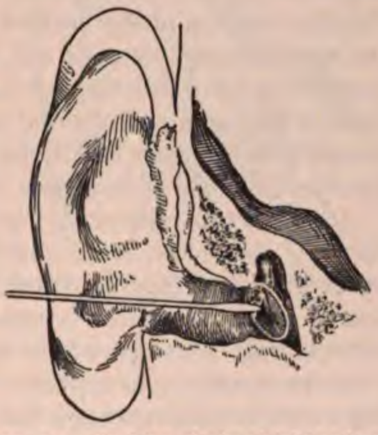


FIG. 133.—Incision of cicatricial band to expose the incudo-stapedial articulation or to free the stapes.

Adhesions following a nonsuppurative inflammation will usually be less amenable to operative treatment than those developing in the residual purulent cases. The reason for this is that in the nonsuppurative cases the constricting bands are seldom confined to any one locality, but involve the entire ossicular chain and the pelvis ovalis as well. The condition is one demanding extensive and sometimes repeated operative measures, and the best results are obtainable by first removing the membrana tympani and the two larger ossicles. This procedure permits a thorough inspection of the pelvis ovalis and of the stapes, and enables the operator to resort to repeated surgical procedures or mechanical measures for the relief of tension existing in this locality, while the primary operation eliminates anomalies in tension arising from other causes.

III. OPERATIONS INVOLVING THE OSSICULAR CHAIN.

(*a*) *Excision of a Portion of the Manubrium Mallei and of a Large Part of the Membrana* was proposed by Wreden * in cases where it was deemed advisable to secure a permanent opening into the tympanum. The procedure has fallen into disuse, since it does not accomplish the desired end. The technique needs no special description, consisting merely of making a circular incision of the desired size by means of a sharp knife, the umbo being taken as the centre. After the section has been completed, the fibrous lamella which it encloses will be held by the manubrium alone, and may be removed by cutting through the malleus handle by means of an écraseur, cutting forceps, or other appropriate appliance.

(*b*) *Disarticulation at the Incudo-stapedial Joint, or Division of the Long Arm of the Incus and Mobilization of the Stapes.*—This procedure is of especial value in the residual purulent cases where the articulation is exposed, or is covered by a thin cicatrix only, through which it is easily visible. It is of less value in chronic nonsuppurative inflammation, since the opening which is made through the membrane to expose the parts soon closes, rendering it almost impossible for the surgeon to relieve by secondary operation any unfavorable results attending cicatrization. Where the long arm of the incus and the posterior crus of the stapes are exposed, disarticulation is effected by means of the angular knife shown in Fig. 123, *f* and *g*, which is inserted behind the descending process of the incus, and made to pass through the articulation by cutting downward. Any portion of the capsule undivided may be severed by inserting the point of the knife below and cutting upward, and by hooking the knife around the anterior aspect of the long process of the incus and cutting downward. It is usually advised that the joint be opened from behind, the resistance offered by the stapedius muscle rendering this the simplest procedure. While this is theoretically correct, there are several objections to its performance. Frequently the long arm of the incus lies so near the margin of the ring that considerable force is necessary to introduce the knife behind it. If disarticulation is accomplished before the stapedius muscle is divided, the retraction of this muscle may pull the stapes completely out of view and render subsequent mobilization impossible. It is advisable, therefore, to divide the stapedius tendon and the adjacent adhesions as the first step of the operation. This is done by inserting a sharp straight knife behind and above the head of the stapes, between it and the tympanic ring, carrying it inward until the point touches the inner tympanic wall, and then cutting directly downward (Fig. 134). By this procedure the stapes, and hence the articulation, is released and brought clearly into view by the traction of the tensor tympani muscle and of the cicatricial bands situated in the anterior part of the cavity. The anterior aspect of the descending crus of the incus is now in such a position that the joint may be easily divided by applying the angular knife to it and cutting downward and backward (Fig. 135), or in some instances it may be more convenient to

---

* Monatsschrift für Ohrenheilkunde, vol. i, p. 22.

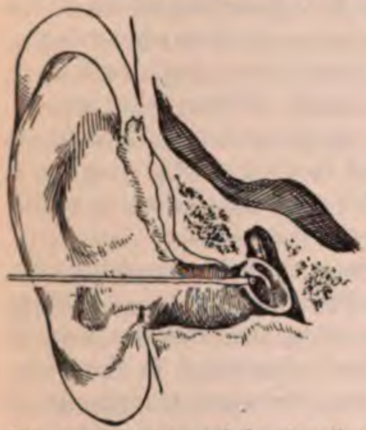


FIG. 134.—Division of the stapedius tendon and of adhesions behind the stapes.

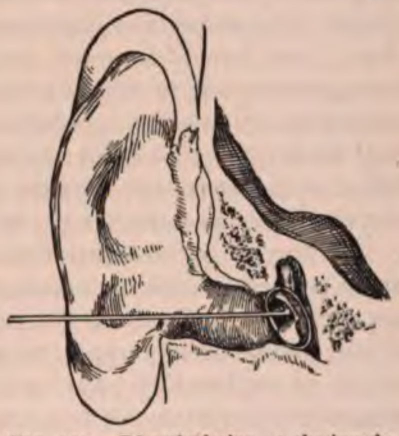


FIG. 135.—Disarticulation at the incudo-stapedial articulation.

enter the joint from below, with the point of the knife, sweeping the blade anteriorly and posteriorly until the capsular ligament is divided. After disarticulation the process of the incus is pushed upward and forward to prevent reunion. The stapes is next examined with a probe, the most suitable instrument being a fine cotton holder, the tip of which is firmly wound with a delicate pledget of cotton. If the ossicle is rigid, it is to be freed by passing the pointed knife about the foot plate, dividing all adventitious bands which may be found within the pelvis ovalis, passing from its walls to the crura of the stapes. After incision, mechanical mobilization by means of the cotton-tipped probe should be effected. The instrument is introduced below the stapes first, and an attempt made to crowd the ossicle upward by a leverlike action of the probe. The same manipulation is repeated from above downward, from behind forward, and from before backward, care being taken not to fracture the crura. Where the incudostapedial articulation is ossified, the long arm of the incus may be divided by a stout scissors,* the fragments being separated so as to prevent reunion, after which mobilization of the stapes is carried out after the manner described.

In chronic nonsuppurative cases Miot † advocated the same procedure, the structures within the middle ear being exposed by an exploratory incision along the posterior margin of the membrana tympani, as already described in the technique of exploratory myringotomy. General anæsthesia is not necessary either in the residual suppurative, or nonsuppurative cases.

Mobilization in the nonsuppurative cases is less effectual if the exploratory incision is allowed to heal than where a permanent opening is maintained, either by the removal of the entire membrane, malleus, and incus, or by allowing the flap to remain displaced, although by the latter procedure it is seldom possible to secure a permanent perforation. The lack of success when the flap is replaced is due to a recurrence of the condition, the closure of the opening rendering it impossible to deal with this surgically except by repeating the original operation.

(*c*) *Plastic Operations for the Purpose of uniting the Incus or the Stapes to the Membrana Tympani Directly.*—The object here is to exclude the two larger ossicles from the physical process of sound conduction, so that the sound waves falling upon the membrana tympani shall act immediately upon the stapes. Little success has attended these procedures, although in exceptional cases they may be valuable.

---

* Politzer, Archiv für Ohrenheilkunde, vol. xxii, p. 122.

† Revue de laryngologie, 1890, p. 49 *et seq.*

A triangular flap of the membrane is turned aside from the posterior superior quadrant, exposing the incudo-stapedial articulation; the mobility of the incus is determined by means of a probe; adhesions about the stapes are severed according to the rules already laid down until this ossicle and the incus move freely. The triangular flap is then applied directly to the long arm of the incus and held in place by a small pledget of cotton or by a small paper dressing. If the incus can not be freed, disarticulation at the incudo-stapedial joint is performed and the flap applied to the head of the stapes instead of to the long arm of the incus.

(*d*) *Removal of the Ossicular Chain in its Entirety, or Removal of Individual Ossicles.*—Removal of the ossicular chain may be attempted either for the improvement of hearing or for the relief of a long-continued suppurative process, or for both conditions. Since the technique is somewhat different, according as the condition results from a suppurative or nonsuppurative inflammation, the operative procedure applicable to cases where the membrana tympani is intact will first be described in detail, after which attention will be given to the particular variations demanded in cases where there has been destruction of the membrana tympani over a large or small area. We have to consider, then—

1. Removal of the malleus and incus.
2. Removal of the malleus, incus, and stapes.
3. Removal of the stapes.

If the membrana tympani is present, this is also removed as completely as possible in carrying out the first two operations, while in stapedectomy the membrane is allowed to remain.

As early as 1873 Schwartze [*] advocated the removal of the malleus and the membrana tympani and disarticulation at the incudo-stapedial joint in cases of nonsuppurative inflammation. Kessel [†] excised the membrana tympani, malleus, and incus, and mobilized the stapes in a case of complete stenosis of the Eustachian tube, while at an earlier date he had demonstrated that the stapes * might be evulsed from the oval window without serious consequences. In 1885 Lucae † reported fifty-three operations in nonsuppurative otitis media in which the membrana tympani and malleus had been removed and the incudo-stapedial articulation divided. In six of these cases the incus was also taken away. From this time on the current literature contains numerous reports of removal of the ossicles in cases of nonsuppurative inflammation of the middle ear, the procedure being followed by varying degrees of success.

---

[*] Arch. für Ohrenheilk., vol. xxii, p. 128.

[†] Ibid., vol. xiii, p. 69.

Concerning the necessity of general anæsthesia, it may be said that at the present time the entire ossicular chain and the membrana tympani may be removed without the administration of a general anæsthetic in patients having a fair amount of self-control. No discomfort is experienced during the entire procedure except at the moment of making the initial puncture, and, when the knife employed for the purpose is in perfect condition, the incision through the membrana tympani in the posterior segment just within the cartilaginous ring is not painful and sometimes is not felt. When the tympanic cavity has been entered the application of a ten-per-cent solution of cocaine by means of a cotton-tipped probe renders the subsequent steps absolutely painless. It is necessary to proceed slowly, as the local anæsthesia is confined to a limited area beyond the extent of the incision, and as the operation progresses the cocaine solution is to be applied from time to time to the edges of the wound and introduced into the tympanic cavity through the artificial opening whenever the patient gives evidence of feeling the manipulations in the slightest degree. Naturally this prolongs the operation; but the advantage gained of testing the results of the various steps of the operation, together with the increased delicacy of manipulation possible when the patient is conscious and able to maintain his head in any position in which it has been placed, more than compensates for the loss of time.

Technique of the Removal of the Membrana Tympani and Ossicles when the Membrana Tympani is Intact.—With the sharp knife (Fig. 123, *e*) an incision is made through the membrana tympani in the upper and posterior quadrant, commencing just below the point where the posterior fold meets the tympanic ring, and following this curve, is carried downward to about the middle of the posterior border of the ring. This incision is made close to the insertion of the membrana, but should lie entirely in the clear membrane, for the reason that if this is done no hæmorrhage results. For the same reason care must be taken not to wound the inner wall of the tympanum with the point of the knife, as any bleeding greatly obscures the field of operation and renders the succeeding steps more difficult. The edges of the incision are now separated and the incudo-stapedial articulation is usually clearly and easily exposed. If sufficient space is not gained, a horizontal incision may be made from the upper extremity of the first, forward toward the short process of the malleus, the section following the course of the posterior fold and lying just below it, thus avoiding the more vascular tissues. If this does not give sufficient room the incision may then be carried downward just behind the long process of the malleus, as in exploratory myringotomy (Fig. 127). In this way a flap is formed which, on being turned downward, enables the operator to see the incudo-stapedial articulation clearly (Fig. 136). The next step is the division of the stapedius tendon; this may sometimes be seen running from the neck of the stapes backward and disappearing behind the tympanic ring; frequently, however, the head of the stapes lies so close to this structure that the tendon can not be seen; in such a case the pointed knife used in dividing the membrana tympani is inserted close to the head of the stapes and slightly above it and carried inward until the inner wall of the tympanum is reached; a short cut downward is then made, carrying the

---

* Arch. für Ohrenheilk., vol. xi, p. 199.

† Ibid., vol. xx, p. 228.

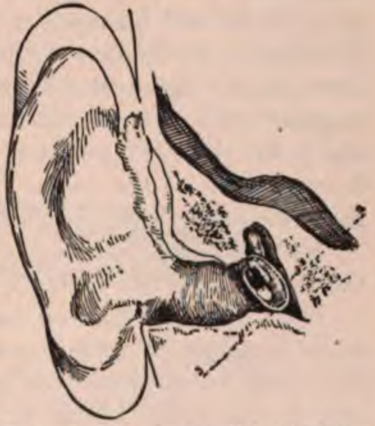


FIG. 136.—Incudo-stapedial articulation exposed by displacement of a flap from the membrana tympani 3, Horizontal incision at lower portion of membrane; 2, The dotted line indicates the incision severing the peripheral attachment of the membrane.

knife between the head of the stapes and the tympanic ring, while the point is still firmly pressed upon the inner wall of the tympanum (Fig. 134). In this way the muscle is thoroughly divided. When the tendon can be seen its division is perhaps more simple; but in either case the point of the knife should be firmly pressed against the inner wall of the tympanum, in order that the tendon and any adhesions about it may be thoroughly and completely severed.

As soon as this has been done the action of the tensor tympani will bring the incudo-stapedial articulation and the stapes more clearly into view. The next step is the division of the incudo-stapedial articulation which is effected with the angular knife. The knife is inserted into the handle in such a way that the point is directed backward and is carried into the tympanic cavity in front of the long arm of the incus, and the blade passed to the inner side of this process (Fig. 135); by slight pressure backward the shaft of the instrument is kept close to the descending process of the incus, while at the same time the instrument is pressed inward, so that the angular blade will lie against the internal tympanic wall; the articulation is divided with a downward stroke. If fibres of the capsular ligament still remain undivided posteriorly the angular knife is to be turned in an opposite direction, with the point directed forward, when, by passing it behind the long process of the incus, a downward stroke will complete the division.

If these steps have been carried out as indicated it will be the exception if more than a drop of blood has been lost.

Next, with the pointed knife, a short, horizontal incision is made through the membrana tympani at its most dependent part close to the insertion into the annulus tympanicus (Fig. 136, 3); the pointed knife is quickly laid aside and the probe-pointed knife (Fig. 123, *c*) is inserted, and the membrane is divided along its posterior periphery from below upward until the exploratory incision is encountered. In the same manner the anterior segment of the membrane is divided from below upward with the probe-pointed knife, the incision extending as far as, but not into, Shrapnell's membrane. (The incision is indicated by the dotted line, 2, in Fig. 136.) Up to this point no blood has been lost and the field of operation is as clear as when we started. There remains to be divided the membrana flaccida and the ligaments which bind the ma leus externally, in front and behind. The pointed knife is again used for this section, which should be made rapidly. The knife is held so that the flat surface of the blade looks toward the roof of the canal, the cutting edge being directed backward; the point of the knife is entered just above the short process of the malleus and is pushed inward and upward, the handle being depressed so that the shaft often touches the margin of the speculum. In this manner the knife is made to enter the fornix tympani; it is now made to cut its way out, downward and backward, thus severing the external and posterior ligaments of the malleus and dividing the membrana flaccida posteriorly. The knife is then quickly turned and made to cut in the opposite direction, being carried forward over the short process, dividing the anterior segment of the membrana flaccida, some fibres of the external ligament, and the strong anterior ligament of the malleus. The malleus is now held only by the superior ligament and the tendon of the tensor tympani, neither of which is strong. The hæmorrhage from the last incision may be free and may obscure the field, but usually, owing to the elevated position of the head, the upper part of the field is not obscured, and the short process of the malleus can be distinctly seen. The ossicle is quickly grasped with the forceps (Fig. 137), just below the short process, and by pressing inward to dislodge the neck of the bone from the projection upon which it rests, followed by traction downward and then outward, the ossicle is extracted. No force is required to rupture the tendon of the tensor tympani or the superior ligament, as they offer very little resistance.

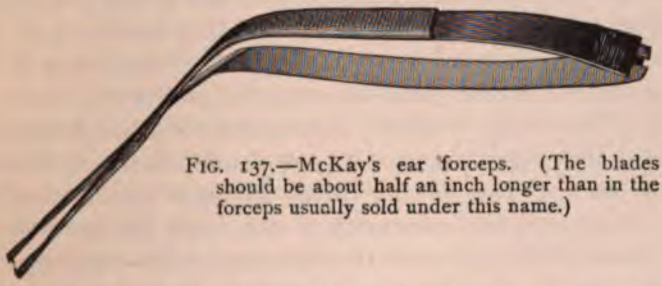


FIG. 137.—McKay's ear forceps. (The blades should be about half an inch longer than in the forceps usually sold under this name.)

It will be necessary now to wipe out the blood which has followed the removal of the malleus, but in most cases a single pledget of cotton will dry the cavity completely. The incus is next sought for, and, if in sight, is grasped with the forceps and removed, traction being at first exerted downward and forward and then outward. Most frequently when the incus is in view the long process will be seen, not in the normal location, but lower down and lying close to the border of the tympanic ring—so close, frequently, that it is overlooked, for it then apparently constitutes a part of the ring. Manipulation by means of a probe reveals its identity and the ossicle can be extracted in the manner already described. This displacement of the incus downward and backward is due to the fact that in the removal of the malleus the capsular ligament binding the two ossicles together must be ruptured. The incus itself is attached to the tympanic wall by means of a single ligament running from its short process to the walls of the fornix tympani. Traction downward on the malleus displaces the incus downward and also revolves it backward, the short process being the fixed point. Thus frequently, after the malleus has been removed, careful inspection of the field of operation fails to reveal any trace of the incus, it having been rotated entirely out of sight behind the tympanic ring. To effect its extraction.is not always easy, and yet in cases where there has been no suppuration it will rarely happen that the ossicle will escape. When not in sight the long process of the incus can be easily brought into view by means of the incus hooks (Fig. 123, *j* and *k*). These hooks are curved in opposite directions for the right and left ear, the concavity of the curve looking anteriorly in each case; the instrument is inserted into the handle with its angular extremity directed upward. The incus hook is introduced into the tympanic cavity and the angular portion passed behind the tympanic ring close to the floor of the canal, the hook being inserted in such a way that the concavity of the hook looks upward. When the angular portion of the instrument has entirely disappeared behind the ring the instrument is drawn outward until it is felt to press closely upon the inner surface of the tympanic ring, when it is rotated forward, at the same time being carried a little upward. Usually this manipulation swings the long arm of the incus into view (Fig. 138). The difficulty sometimes experienced in securing the incus usually lies in the fact that the operator is inclined to search for the ossicle too high up in the tympanum and to forget that the long process lies close to the margin of the ring;

the hook is therefore frequently carried too deeply into the tympanic cavity and fails to engage the long process. This manœuvre is to be repeated several times in case the first effort is not successful. If no free body is felt with the hook it is then inserted into the tympanum at the antero-inferior portion with the concavity of the hook directed posteriorly; the hook is now rotated, sweeping the extremity which touches the tympanic ring closely, backward, and at the same time somewhat upward. This manipulation will bring the incus into view in case rupture of the posterior ligament of the incus during the removal of the malleus has allowed the ossicle to fall into the antero-inferior part of the tympanic cavity, an accident which may sometimes happen.

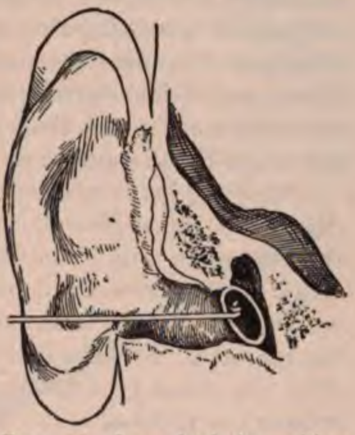


FIG. 138.—Incus hook in position.

If the ossicle is not found in either of these situations, the hook should be swept upward and forward through the postero-superior and superior portions of the tympanic cavity, keeping it still pressed firmly against the internal margin of the ring. Care is to be taken in this manipulation that the hook does not pass between the crura of the stapes or fracture them as it is carried forward. If the incus still remains hidden, the hook having the opposite curve should now be carried into the fornix tympani with the concavity directed backward, the angular portion of the instrument being hooked behind the inner extremity of the superior wall of the meatus. The instrument is now rotated backward, and at the same time is carried downward, rotation being continued through an angle of one hundred and eighty degrees. This manipulation will dislodge the incus in cases where its posterior ligament is very strong, or where the long process has been rotated far backward out of reach of the hook. After this downward sweep it is well to repeat all of the steps for dislodging the incus in the order named, as this last manipulation may displace the ossicle downward, although it may still remain hidden from view. The objection to beginning the search in the manner last mentioned lies in the fact that, if the ossicle is already free or nearly so, the manipulation is apt to displace it so far toward the mastoid antrum as to render it entirely inaccessible. I have written upon the method of extracting this ossicle somewhat at length, because I believe it to be extremely important to remove it if possible; and I feel certain that the advantages gained by its extraction are more than enough to warrant prolonging the operation for this purpose.

After the incus has been removed, the cavity is thoroughly dried and the region of the round window inspected. Any thickening in this situation should be overcome by cutting away the hypertrophied tissue if possible. Usually, however, we find simply a thickening of the mucous membrane about the fenestra. Stellate incisions by means of an angular knife (Fig. 123, *f* and *g*,), introduced into the niche, most frequently relieve the tension.

The stapes is next inspected and its mobility tested. If rigid, all adhesions about it should be divided and the ossicle mobilized with the cotton-tipped probe, in the manner already described; if its motion is now free, the operation may be considered completed. If, on the other hand, the motion of the stapes is still impeded, or if the adhesions have been found to be so extensive that, after they have been divided, cicatrization will probably render the ossicle rigid again, the stapes may be removed. All soft tissue binding it down should be carefully severed with the sharp knife passed around the foot plate, after which a delicate hook (Fig. 123, *b*) is passed between the crura and the ossicle is removed by traction. It is often more easy to grasp the head of the bone with the forceps and remove it in this way than by making use of the hook.

In cases where difficulty is experienced in finding the incus, and it is deemed necessary to remove the stapes—this ossicle being easily seen—it is often wise not to delay the removal of the stapes until the incus is found, since, in the manipulations necessary to displace the incus, the crura of the stapes might accidentally be broken or the head of the bone be so displaced as not to be easily seen. Hence, if the incus is not readily found, and it has been found advisable to extract the stapes, this may be removed as the second step of the operation, and the incus subsequently searched for.

If the stapes is removed at this stage of the procedure, care must be taken in searching for the incus that the incus hook is not passed through the oval window, thus injuring the labyrinth. This may seem a needless precaution; but any one who has studied the parts upon the cadaver will appreciate how easily the incus hook can be passed through the thin membrane covering the fenestra ovalis. The reason of this lies in the fact that the plane of the oval window is not vertical, but inclined downward and outward. When this opening is situated high up, and is almost hidden by the tympanic ring, the incus hook may be easily carried under its upper margin and through the membrane covering the opening, the operator mistaking the resistance offered for that of the tympanic ring. If the posterior wall of the canal is closely followed and the incus hook made to enter the tympanum low down, and is afterward applied closely to the tympanic ring, this accident can not occur.

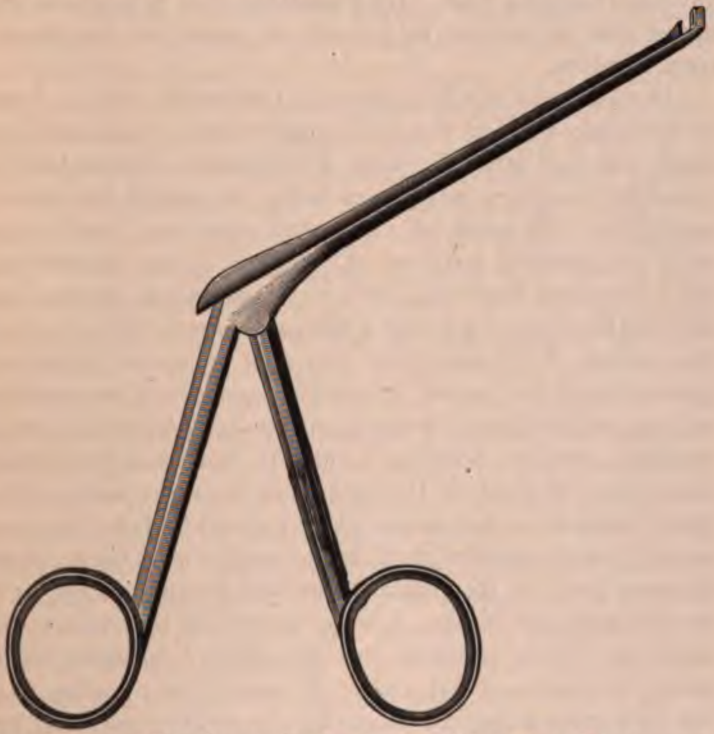


FIG. 139.—Author's cutting forceps for the removal of a portion of the inner extremity of the external auditory canal.

In some instances the margin of the tympanic ring hides the stapes so completely that this ossicle can not be seen, and it is impossible to form an intelligent opinion as to its condition or to effect its removal. In such an event the margins of the ring in this situation may be cut away by means of the forceps shown in Fig. 139. This forceps is so constructed that when open the distal extremity of the lower blade can be passed up behind the tympanic ring. Upon closing the instrument, the chisel blade cuts away a small chip from the overhanging wall. By repeating this procedure enough space can be gained to permit of access to the stapes and oval window.

Occasionally the foot plate of the stapes will be found to be so firmly fixed in the oval window that it can not be loosened, and that after dividing all adhesions its removal is impossible, the crura sometimes being broken in the attempt at extraction. In such an event the operator should proceed with the greatest caution. All the soft tissues should be carefully removed from the oval niche by means of the angular knives (Fig. 123, *f*, *g*) and a delicate curette (Fig. 123, *a*). If the outline of the foot plate can now be made out, a pointed knife should be carried around its periphery in the hope of making an opening at some point where the union is less firm; through such an opening a delicate hook can be introduced and a part at least of the foot plate brought away. If complete ossification has taken place I should advise the cautious use of a small guarded drill, which might be made to perforate the foot plate at its centre, after which portions might be removed with the hook. I have never had occasion to do this upon the living subject, but should not hesitate to do so, using, of course, great care. It would be possible to carry out this step without evacuating the perilymph; but even if a small quantity of the fluid should be lost, Kessel's observations have proved that no harm results. It need hardly be said that such interference is justifiable only in cases where absolute asepsis has been preserved.

After all the operative steps deemed necessary have been carried out, the cavity is to be dried with pledgets of cotton and a tampon of iodoform gauze or a long pledget of cotton introduced. This is carried completely into the tympanum and should fill the canal but loosely. The object of the gauze is to check any oozing which may occur and to serve as a drain, thus preventing the formation of a blood clot within the middle ear; if this is allowed to form it may give rise to considerable pain by preventing the escape of secretion during the first days after the operation. If there is much pain a few hours after the operation this tampon is removed and the ear is douched with a warm, weak antiseptic solution (as, for instance, a saturated solution of boric acid or a solution of bichloride of mercury, 1 to 8,000), after which the tampon is reinserted. When the odor of iodoform is objectionable, sterilized or borated gauze may be used. This second tampon is allowed to remain in position for twenty-four hours, and in cases where there is no pain after the operation the first tampon is not disturbed for twenty-four hours. This tampon is placed so deeply as to be out of the reach of the patient, while a pledget of cotton is placed at the orifice of the meatus to collect any serous transudate. The patient is allowed to change this outer pledget as often as it becomes saturated, but leaves the deeper one undisturbed. The subsequent treatment depends upon the amount of local reaction following the procedure. If there is but little discharge, the cleansing of the ear once daily by the surgeon, followed by the insufflation of boric acid, dermatol, or some kindred powder, will be all that is necessary. If the mucous membrane over the internal tympanic wall appears healthy and there is little or no secretion, the best results will be obtained by keeping the canal aseptic by gently wiping the walls with a solution of bichloride of mercury (1 to 5,000) in fifty-per-cent alcohol, leaving the tympanic cavity undisturbed. If any powder is insufflated it should in these cases be applied to the walls of the canal only, and should not enter the tympanum. When the middle ear is not inflamed, any interference retards the progress of the case rather than favors it. If the patient can not be seen daily, as is usually the case in dispensary practice, gentle syringing of the ear once or twice daily, according to the amount of discharge, if any appears, is all that will be required, but I have never thought it wise to trust the insufflation of any powder to the patient. When the discharge is only slight, even the syringing is objectionable, and an intelligent patient may be allowed to cleanse the ear by simply wiping it out with a pledget of cotton wound upon an appropriate cotton holder. On the other hand, if at the end of a week there is still considerable secretion, the patient is directed to instill a few drops of a solution of boric acid in alcohol of a strength of twenty grains to the ounce, after each syringing. The amount of discharge after the operation will depend upon the habit of the patient and also upon the condition of the mucous membrane of the tympanum. In cases of advanced sclerosis the amount is frequently insignificant, especially if the patient is not of a full habit. On the other hand, when the tympanic cavity or the fornix tympani has been full of connective tissue rich in blood vessels, the discharge following the operation will be more profuse. It is probable, also, that prolonged manipulation within the cavity at the time of the operation favors a more profuse discharge, although this is certainly not true in all cases, and should not deter the operator from doing a deliberate and thorough operation.

I have written somewhat at length about the management of the cases after operation because I consider this an important point. In a general way, the less that is done after the operation, the more likely we are to obtain a permanent opening into the tympanic cavity, a condition always to be desired. Hence the aim should be to keep the ear clean with as little manipulation as possible, and to avoid the use of astringents or caustics to stop the discharge, since they will certainly promote the reproduction of the tympanic membrane.

The amount of disturbance caused by the procedure described is very slight. Of forty cases, both purulent and nonpurulent, thirty-five left the hospital twenty-four hours after the operation and resumed their regular daily work without the least trouble, and quite a number returned home upon the evening of the same day, the operation having been performed in the afternoon. Of course the stapes was not removed in all of these cases; and when this ossicle is taken away I prefer to confine the patient to the house for twenty-four hours at least. Yet in three cases of stapedectomy the patients returned home in less time than this without any unpleasant effects, while in two cases in which this ossicle was left *in situ*, but had been subjected to considerable manipulation in securing the incus, dizziness persisted for several days after the operation. As a rule, when the two larger ossicles alone are to be excised, the patient can be assured that any disturbance sufficient to incapacitate him for work will not last more than twenty-four hours—an item of importance among those who find it impossible to obtain a longer respite from their daily vocation. Of this we can be as certain as in allotting the same period for the disappearance of the unpleasant effects of general anæsthesia, and the surgeon is justified in promising that the effects of the operation will not detain the patient after the disturbance due to the anæsthetic has passed away.

When the stapes is to be removed, however, the dizziness may make locomotion difficult for a somewhat longer period, and if there is a probability that this will supervene it is not wise to promise that this giddiness will not interfere with locomotion for several days, although in many cases the giddiness will disappear rapidly. If the malleus and incus alone are removed it will be decidedly rare for any such disturbance to follow.

I have never met with pain or severe local inflammation as the result of these operations, for the reason, I believe, that perfect drainage exists. In this respect I feel certain that the complete removal of the ossicles and membrane commends itself, when compared with some of the intratympanic operations in which less positive violence is done but in which free drainage is not secured.

As regards the reproduction of the membrana tympani, my experience has been that, as a rule, the membrane will reform, although this is not always the case. The membrane which reforms is usually thin and not as sensitive as the normal membrane, and its removal is but a trivial measure. Again, its reproduction does not always impair the result of the operation. In cases in which, after the membrane has been reproduced, the hearing becomes worse than while a perforation was present, it should be removed. General anæsthesia, in my experience, has never been necessary. The first incision through the membrane is slightly painful, after which a few drops of ten-per-cent aqueous solution of cocaine introduced into the tympanic cavity by means of the cotton-tipped probe renders the operation painless. If previous experience has shown that cocaine produces unpleasant symptoms, either a saturated solution of eucaine (B) or a twenty-per-cent solution of alypin may be used. The operation is best performed by passing the sharp knife (Fig. 123, *c*) through the membrane close to the tympanic ring and just below the head of the stapes and dividing the posterior attachment of the membrane close to the ring for a short distance, great care being taken not to wound the mucous membrane of the tympanum. The probe-pointed knife should then be substituted and the attachment followed downward to its lowest point. It will then be found that the tissue is so relaxed that division of the anterior attachment is difficult; to overcome this the sharp knife is again passed through the membrane at its lower part just in front of the point where the posterior incision terminated. A little pain is usually experienced from the incision, but it is only momentary. The anterior attachment is now divided from below upward with the blunt knife until the incision meets that which severed the posterior attachment. Usually the relaxation interferes with the complete section. The membrane is now held by a thin strip of tissue above and below. A touch with the sharp knife severs these attachments or weakens them to such an extent that the entire membrane may be easily removed with the forceps. If it is too firmly held, the small scissors (Fig. 128) will be found useful. The procedure is so simple that, if attention is given to secure an aseptic condition of the instruments and field of operation, no reaction results. The operation may safely be performed at the office of the physician and the patient at once allowed to resume his usual duties. It is well to protect the ear by the insertion of a cotton pledget which need not be worn for more than forty-eight hours after the removal of the new membrane. After this it is well for the patient to occlude the meatus with a cotton pledget when out of doors. At the end of five or six days no protection is necessary. The patient should be cautioned against taking cold; but further than this no special precautions are to be advised. The procedure is not likely to be followed by any discharge, and all syringing of the ear is to be avoided unless pain or profuse discharge supervene, as disturbing the parts in any way may excite enough reaction to cause a reproduction of the membrane.

One point is worthy of special attention, and that is that the removal of a membrane which has formed after operation should not be undertaken until all traces of inflammation have disappeared. The surgeon must wait until the newly formed tissue is pearly white and glistening and until the mucous lining of the tympanum has also assumed its normal condition, as evidenced by the absence of redness, engorgement of its vessels being easily made out through the thin cicatricial membrane. If this rule is not observed the operation will be more painful, and reproduction is almost certain. If the membrane reform again, a second or third removal is still more simple, as the density of the tissue is less each time that it is reproduced. In one case this was so marked that after the first incision the edges of the wound retracted so widely that it was possible to remove only a minute portion of the new-formed tissue, and yet the tympanum was freely exposed, and no reproduction has followed at the end of several months.

In plethoric individuals a persistent reproduction of the membrana tympani after excision can be prevented by a restriction of the diet for a few weeks previous to and following the secondary removal of the structure. This is suggested by Sexton,* and I have proved its efficacy.

In certain instances it may be found that the new membrane has become adherent to the inner wall of the tympanum, thus rendering its complete removal difficult. In one such case in which the stapes had been left *in situ*, the hearing remaining impaired, apparently on account of the stapes being bound down by the newly formed membrane, this was divided first behind the head of the stapes and the incision was carried downward close to the tympanic ring for a distance equal to about one third its posterior margin. The stapes then lay free, while in front there was a flap attached by adhesions to the inner tympanic wall; this flap was turned forward and the underlying wall of the tympanum was scarified, after which the flap was replaced and pushed down upon the wall of the middle ear, care being taken that the free margin lay below the tympanic ring. Adhesion at once resulted, leaving the stapes projecting into the canal, while the tympanic cavity was largely obliterated from the adhesion of the membrane to its inner wall. Thus the middle ear was thoroughly protected by a cutaneous covering, while the parts essential to audition remained accessible for further operative procedure. The patient, though better, is still under treatment, and I hope for still further improvement following the division of remaining bands which partially fix the stapes. It may be advisable in certain cases to preserve the anterior portion of the membrana tympani in removing the malleus and incus, and, after scarification of the inner wall of the tympanum, to attempt to secure adhesion of the anterior segment of the membrana to this structure. In this manner we might shut off the anterior part of the tympanic cavity from the posterior portion which contains the parts especially concerned in audition. The posterior portion would become covered by epithelium from the surface of the membrana tympani, and the objection of having an exposed mucous surface would be avoided. We could by care secure a thin epithelial covering for the round and oval windows, the stapes being removed or not, according to indications. I have never performed the operation with this object in view, but, from the fact that Nature occasionally succeeds in doing this unaided, it may not be out of place to suggest it here as worthy of a trial.

---

* The Ear and its Diseases, New York, 1889, p. 392.

Technique of Operation where the Membrane is Partially or almost Completely Destroyed.—Where the ossicles are to be removed for the relief of a purulent inflammation general anæsthesia should be employed, since removal of the ossicles alone constitutes but a small part of the operation. The pathological process is seldom confined to these structures, but has involved as well the bony walls of the tympanic cavity, and it becomes necessary to curette thoroughly the entire space if the process is to be permanently checked. In these cases also the malleus and incus are frequently destroyed in large part, nought but minute fragments remaining. To secure these fragments, prolonged, and sometimes forcible, manipulation becomes necessary, and a thorough operation is possible only under general anæsthesia.

When a purulent inflammation has resulted in the destruction of a considerable portion of the membrana tympani, the method of procedure must be modified to a certain extent. In some of these cases we shall find the lower portion of the membrana wanting, the membrana flaccida thickened and highly vascular, binding the ossicles down and concealing them more or less completely. We may be able to recognize by inspection only the prominent short process of the malleus and a portion of the manubrium, the latter lying almost horizontal, its tip bound firmly to the upper part of the inner tympanic wall. Behind the short process examination with a probe reveals the incus and stapes as present, but whether in their entirety or not can not be determined. In other cases, while there may have been extensive destruction of the membrana tympani, the posterior superior segment is covered with a thin cicatricial membrane, through which the incudo-stapedial articulation is plainly seen, or this joint may be completely exposed, no covering being present. My rule has been, in all cases where the incudo-stapedial articulation is visible, or where this region is covered by a nonvascular membrane the division of which will not lead to annoying hæmorrhage, to divide first the stapedius muscle and then the incudo-stapedial articulation in the manner described when considering the method of operation in cases in which the membrana is intact. When, however, it is evident that an incision in this region will be followed by hæmorrhage, such a step serves only to complicate the operation, as the bleeding will render it impossible to see the incudo-stapedial joint, much less to disarticulate with certainty, and will frequently completely obscure the field of operation, hiding even that most prominent and important landmark, the short process of the malleus, so that considerable difficulty may be experienced in removing even this ossicle. Experience shows us that when this condition is present there is very little hæmorrhage after the membrana flaccida has been completely freed from its attachments and removed, together with the malleus. Our first step, then, will be to insert the straight pointed knife above the short process, pushing it inward and upward until the inner wall of the tympanum is encountered; it is then made to divide rapidly the attachments of the remnant of the membrane to the tympanic ring by directing its edge backward and incising close to the margin of the ring; without removing it from the wound, the edge is turned in the opposite direction and divides the anterior attachments. In cutting backward, the operator must bear in mind that the incudo-stapedial articulation has not been severed, and in this region as little force as possible should be used. For this reason, also, the posterior incision should be made first as above directed. Almost immediately the fundus of the canal fills with blood, but for a few seconds at least the short process is plainly visible; and if examination has shown us that the manubrium is not firmly bound to the promontory, the malleus is at once seized with the forceps just below the short process and removed in the manner already described. If, however, firm adhesions are known to exist, or if the malleus is found to be firmly fixed on grasping it with the forceps, no force should be used to effect its removal, but the canal should at once be tamponed firmly with cotton by carrying an elongated plug saturated with a 1-1,000 solution of adrenalin chloride, into the tympanic cavity with the forceps and pressing it firmly upon the internal tympanic wall. Upon this tampon a second and third are crowded until there is no bleeding about the plugs. If this packing is allowed to remain in position for a few moments and then removed with the forceps, the field of operation will be found to be dry, the bleeding having been entirely checked. Any given area can be more completely cleansed by touching it with a small pledget wound upon a cotton-holder. The adhesions binding the malleus to the promontory can now be divided with the blunt knife curved on the flat, after which the ossicle is removed by means of the forceps. If the malleus is still firmly fixed, manipulation by means of the probe will determine the situation of the undivided attachments and their section can be effected.

When it has been possible to divide the incudo-stapedial articulation as the initial step, I frequently remove the malleus in the manner described as the second step of the operation, in place of the first, after freeing the remnant of the membrane from its peripheral attachments below, anteriorly and posteriorly. This, of course, applies to cases in which the greater portion of the tympanic membrane has been destroyed. When only a comparatively small portion of the membrana vibrans is wanting and excision is deemed proper, it may be well, after dividing the incudo-stapedial articulation, to sever the peripheral attachments of the membrane from below upward by means of a blunt knife introduced through the perforation. As a rule, however, so many adhesions exist between the inner tympanic wall and the lower portion of the membrana that such a procedure is unadvisable. Moreover, the parts are frequently so vascular that the attendant bleeding may complicate the more important part of the procedure—the division of the superior attachments and the removal of the malleus. It is usually wiser in these cases to divide the upper segment first, the knife being carried into the perforation in terminating the posterior and anterior incisions.

It may seem hazardous to subject the stapes to the possibilities of violence attendant upon removal of the malleus before the incudo-stapedial articulation has been divided. A moment's reflection will convince one, however, that the presence of firm connective tissue which renders the procedure necessary also fixes the stapes so firmly that intelligent manipulation can scarcely displace it, while the danger of inflicting such an injury is much greater if an attempt is made to divide the articulation with the field of operation partially obscured by blood. Again, it frequently happens that the long process of the incus has become necrotic and the articulation has been destroyed, so that no connection between the two ossicles exists.

After the malleus has been removed, the stapedius muscle and incudo-stapedial articulation should be found and divided, unless this step has already been performed, after which search is made for the incus in the manner already fully described. It should be remembered that as caries more frequently attacks the incus than any other ossicle, it may be partially or completely destroyed. In the former case its removal is often difficult, while it is important to determine with certainty the latter condition, to avoid a prolonged search if it is absent. It should also be borne in mind that the pathological process may have resulted in a bony union between the incus and malleus, and that both ossicles may be extracted together. In case both ossicles were intact, the operator could not overlook such an occurrence; but when one or both have been partially destroyed, careful inspection of the portions removed may be necessary, to determine the simultaneous removal of the malleus and incus. The operator should then, upon extracting what he supposes to be the malleus, carefully examine it, in order to assure himself that the body of the incus is not attached thereto. If nothing but the malleus is found, the field of operation should be dried and inspected carefully. If no portion of the incus is seen, special attention should next be given to the postero-superior segment of the field. It sometimes happens that the incision has not been close to the tympanic ring in this region, a circumstance not easily recognized unless the parts are touched with the probe, when it will be found that a small curtain, or flap, of tissue remains undivided. The destruction of a small part of the ring at this point, as the result of caries, also gives rise to a similar appearance. It quite frequently happens that the incus is adherent to this flap, or completely concealed by it. Division of the soft parts close to the bony margin will, in such a case, bring the incus into view. If not found in this situation, the ossicle must be searched for with the incus hook, in the manner already described while considering the operation in cases with an intact membrana tympani. If all of these manipulations fail to bring the incus into view, or if it has not been felt, and the incus hook can be carried freely from behind forward, through the vault of the tympanum, the operator may decide that the ossicle has been destroyed by caries, or that it has suffered partial destruction, and the remaining portion has become amalgamated with the tympanic roof. If, however, it has been seen or felt at any time, its subsequent loss will mean dislocation into the mastoid antrum.

The management of the stapes and the region of the round window is conducted in the manner already described.

Any parts of the membrana tympani which may remain in the lower portion of the fundus are to be removed with the knife, curette, and forceps if they are the seat of a hypertrophic process, as evidenced by considerable thickening and increased vascularity, for they may conceal areas of bony necrosis. If, however, the appearance of the lower portion of the membrane is healthy, we may feel certain that the bony structures are unaffected, and that there is no indication for the removal of the lower portion of the membrane—in fact, its presence will hasten cicatrization.

After drying the tympanum thoroughly, we should next search for softened bone, both by inspection and with the probe. Inspection will often reveal here and there unhealthy granulation tissue indicative of the presence of dead bone. The probe should be made to traverse carefully the entire inner wall of the tympanum, and should also be bent at a right angle at the tip, to enable the surgeon thoroughly to explore the tympanic vault. The curette should then be freely used, and all granulation tissue and softened bone should be removed. For the atrium the straight curette (Fig. 123, *a*) will be found serviceable, but for the vault the sharp spoons, bent at a right angle (Fig. 123, *h*, *i*), must be called into requisition. This procedure of thoroughly removing exuberant granulations and curetting the walls of the entire cavity is of the greatest importance, and should be conducted with special care, as the ultimate success of the operation often depends quite as much upon this step as upon the removal of the ossicles. An area of softened bone in the vault of the tympanum will keep up the discharge for a long time, and render the result of the operation far from satisfactory. Hence quite as much attention should be given to this procedure as to the removal of the ossicula. The curette should also be introduced well into the tympanic orifice of the

Eustachian tube, so as to cause a closure of this tube, if possible, to prevent subsequent infection of the middle ear from the naso-pharynx. After the bony walls of the tympanum have been thoroughly curetted, the margins of the tympanic ring should receive attention. It frequently happens, when long-continued suppuration has existed, that the margin of the ring becomes involved. This is particularly true of the superior and postero-superior margin, on account of its intimate relation to the ossicula, and because it forms a portion of the floor of the vault of the tympanum. Any roughness or softening in this region should be dealt with radically. All diseased areas should be removed with a curette, and a portion of the ring may be excised with the cutting forceps if necessary.

After all these steps have been carried out, the treatment of the case for the first twenty-four hours will not differ from the after-treatment of cases in which the membrana tympani was originally intact. The treatment subsequent to the first twenty-four hours, however, must vary with each individual case. While the discharge continues profuse, the ear must be cleansed by the patient with the syringe and a mild antiseptic solution twice daily, or more frequently if this is necessary to keep the parts clean. At the end of a week, if there is considerable discharge, I recommend the instillation of the solution of boric acid in alcohol twice daily after thorough cleansing. Any granulation tissue must be destroyed, as it appears, by means of chromic acid, silver nitrate, the actual cautery, or any other destructive agent.

As the discharge becomes almost *nil* we may dispense with the syringe, and the patient may be allowed to cleanse the ear by means of pledgets of cotton wound upon any convenient probe, while the surgeon may once or twice weekly insufflate a small quantity of boric acid, dermatol, or other mild antiseptic or stimulating powder, until all discharge ceases.

It has been my good fortune in the majority of such cases either to stop the discharge completely or to diminish it so much that it has ceased to be a source of annoyance. The length of time which must elapse after the operation before complete cessation of the discharge must vary with each case, depending upon the extent of the original involvement. Where the caries has invaded the tympanic walls the discharge will naturally persist for a longer period than when the disease has been limited to the ossicles.

From six to eight weeks is the average time. In some cases cicatrization may be perfect at the end of two or three weeks, while in others the same number of months must elapse.

The technique given varies in some particulars from that advocated by other operators. In the division of the incudo-stapedial articulation the ordinary direction is to enter the knife behind the long arm of the incus and divide the articulation by cutting downward and forward. Those who advocate this plan of procedure say that the pressure of the instrument is then opposed by the action of the stapedius muscle, and danger of injury to the stapes is avoided, while at the same time the resistance of the stapedius renders the division more easy. My own preference is to sever completely the stapedius tendon before attempting to disarticulate, as by this means the articulation is brought more perfectly into view through the action of the tensor tympani and tense ligamentous bands located anteriorly. If the stapedius muscle is not completely divided as the initial step, the stapes, after disarticulation, is frequently pulled out of sight behind the margin of the tympanic ring. After division of the stapedius, disarticulation by the method usually recommended may dislocate the stapes, although this is not likely to occur. It is often difficult, however, to insert the knife between the tympanic ring and the long arm of the incus, and for this reason I prefer the method given in my description of the technique of the procedure—that is, to pass the angular knife in front of the long arm of the incus and open the articulation by cutting downward and backward against the pull of the tensor tympani, or to open the joint at its lower aspect, and then to sweep the knife through it by carrying it backward and forward. By either of these methods the joint is more easily opened than when an attempt is made to carry the angular blade behind the long process of the incus, which frequently lies so close to the tympanic margin that considerable violence must be used in introducing the knife.

In removing the incus Kretschmann,* who was the first to formulate the procedure for removing this ossicle, made use of a hook which, in addition to the curve shown in Fig. 123*jk*, was bent outward at the distal extremity so that when the instrument was in position the tip rested upon that small shelf-like structure of the superior wall of the canal which affords lodgment for the incus. He introduced the instrument with the concavity directed backward, and brought the incus into view by rotation backward and traction downward. While this manipulation is no doubt of great value in certain cases, the backward rotation seems more likely to carry the ossicle far out of reach toward the mastoid antrum in case it is not secured at once, and the manipulation of attempting to bring the long process into view by passing a hook behind it and rotating forward has in my hands proved very satisfactory, while it certainly lessens the danger of displacing the ossicle far backward.

---

* Arch. für Ohrenheilk., vol. xxv, p. 165.

The teaching that it is not advisable to make a prolonged search for the incus seems to me unwise. In nonsuppurative cases careful manipulation will render failure to secure it exceedingly rare. If it has not been displaced it must occupy its original position, and failure to bring the long process into the field of vision will render it impossible for the operator to be certain of a complete division of the incudo-stapedial articulation; or if the head of the stapes is seen lying free in the field, it is certain that the incus has been displaced and, by acting as a foreign body, may give rise to trouble if allowed to remain. If the long process is in view there is no difficulty in removing the ossicle.

In purulent cases it is still more important that the ossicle should be removed. Ludewig * found the incus carious in eighty-five per cent of the cases upon which he operated. In twenty-nine cases of purulent otitis operated upon by the author,† the ossicle was carious in nineteen, while in eight it had been completely destroyed. Prolonged manipulation in searching for the ossicle has not, in my hands, in any way added to the reaction following the procedure, nor has it interfered with the results. I should therefore earnestly advise prolonging the operation for the purpose of securing the incus rather than performing a rapid operation and failing in its removal.

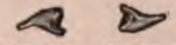


FIG. 140.—Caries of incus. Long process destroyed; articular surface eroded. (Author's specimen, natural size.)

Among the complications which may interfere with the operation, hæmorrhage is the one upon which special empha-

---

* Arch. für Ohrenheilk., vol. xxix, p. 241; vol. xxx, p. 263.

† Supplement to the Reference Handbook of Medical Sciences, New York, 1893.

sis is laid. Since I have operated with the patient in the semi-recumbent position, annoying hæmorrhage has been the exception rather than the rule. If it is sufficient to interfere with the manipulation, it can always be checked by tamponing the canal firmly with cotton pledgets. It is important in executing this manœuvre that the first pledget should be carried well into the tympanic cavity, and also that the pledgets should not be too large, as the removal of a large tampon is likely to lead to a recurrence of the hæmorrhage. This objection is overcome if a number of small plugs are used instead of a few large ones. It may be necessary to repeat the tamponing several times, but it will certainly effect its purpose if a little patience is exercised. In place of the cotton pledgets, a strip of sterile gauze may be used. This is more easily removed than the cotton tampons, and is equally efficient. It has recently been my practice to moisten the strip of gauze with the sterilized suprarenal solution already mentioned. The hæmostatic action of this preparation materially increases the efficiency of the tampon. Schmiegelow * has reported one case in which the hæmorrhage was so severe that he was obliged to discontinue an attempt to excise the malleus.

My own experience with intratympanic operations, more especially the particular class now under discussion, has led me to consider them remarkably free from risk. It is possible, however, for unpleasant sequelæ to follow such procedures. Among these the most important are injury to the facial nerve, deafness from accidental impaction of the stapes into the oval window, injury to the labyrinth from accidental or intentional removal of the stapes, either by direct traumatism or by infection, etc., and inflammation of the mastoid process.

The facial nerve is occasionally injured by the incus hook. The cause of this accident is to be found either in a congenital defect in the Fallopian canal or in the partial or complete destruction of its walls as the result of disease. With the exercise of a little care in manipulating the incus hook, bearing in mind that great force is not necessary to displace the ossicle, the accident can usually be avoided. If the facial nerve is touched by the instrument the twitching of the face immediately warns the operator of what has occurred, and subsequent caution will prevent serious injury. In one of my own cases twitching of the face was noticed while attempting to

---

* Hospitals Tidende, 3, R. V., Nos. 22–26.

locate the incus, and upon recovery from anæsthesia there was marked paresis of the corresponding side of the face; the facial nerve had been slightly involved before the operation, but after this the signs were much more pronounced. The paralysis disappeared under the use of the faradic current. Facial paralysis consecutive to a similar operation occurred also in a case reported by Ludewig.*

In view of the fact that all portions of the tympanic cavity are not accessible through the canal, and in order that the procedure may be more directly under the eye of the operator, Stacke † prefers to expose the parts by external incision. His method is as follows: An incision is made down to the bone just behind the attachment of the auricle, and, following this in direction, is continued from the tip of the mastoid process to a point just above the tragus. With a small elevator the cartilaginous meatus and as much as possible of the periosteum of the osseous canal are separated from the bony parts. In this manner the superior, posterior, and inferior aspects of the margin of the bony meatus are exposed. The soft parts are now divided transversely downward and forward as deeply in the canal as possible, and by traction upon the auricle the funnel-like mass is pulled out of the bony meatus (Fig. 150). The periosteum of the anterior wall is next divided, when the entire cartilaginous meatus and a part of the thin cutaneous lining of the osseous canal may by traction forward be so displaced as to leave the margin of the bony meatus entirely free. The tympanic structures may then be seen by direct light and all affected parts, including the carious ossicles, are removed. By means of the gouge the superior and posterior margins of the inner extremity of the bony meatus may now be removed, and the stapes being protected by a proper instrument, the curette may be freely used in the vault of the tympanum, the manipulations being under ocular inspection. In this manner the entire cavity may be cleared completely of necrotic tissue and the mastoid antrum even may be exposed. In case there is evidence of serious mastoid involvement the original incision is made a little farther back than directed and the antrum entered in the ordinary way, after which the tympanic cavity is exposed and treated in the manner described, and finally the canal and the artificial opening into the antrum are thrown into one. In this way the middle ear, mastoid cells and canal are converted into a single cavity, all parts of which are easily accessible through the external meatus.

---

* Arch. für Ohrenheilk., vol. xxix, p. 259.

† Ibid., vol. xxxi, p. 201. Freilegung der Mittelohrräume. Tübingen, 1897.

After the operation the cartilaginous canal is replaced and a drainage tube is passed into the bony meatus, completely filling its lumen, and thus preventing displacement of the soft parts. Instead of the drainage tube it is quite sufficient to pack the meatus firmly by means of iodoform gauze, the gauze being carried well into the tympanic cavity and applied firmly enough to crowd the soft parts upward and outward against the bony wall of the canal. Contrary to the directions given by Stacke, I do not consider it necessary to carry the transverse incision through the anterior canal wall. It is quite sufficient to incise the superior, posterior, and inferior walls of the fibro-cartilaginous tube, after separating the soft parts from the bony structures to which they are attached. A better view of the deeper parts may be gained if before retracting the anterior flap a horizontal incision be made along the middle of the posterior wall of the fibro-cartilaginous canal, this incision extending from the point where the canal is divided transversely, to a point just within the concha. If, now, a strip of gauze is introduced through the external auditory canal and brought out at the external opening, firm traction on this gauze strip will draw the entire anterior flap forward, and enable the operator to see the fundus of the canal very clearly. The external incision is sutured, all drainage being through the meatus. In cases where the mastoid antrum has been freely exposed it is usual to incise the soft parts of the canal longitudinally along the posterior aspect and press the flaps thus formed backward into the cavity, holding them in position with tampons of iodoform gauze. In this manner a cutaneous lining for the mastoid antrum is secured. The same result is attained by cutting a quadrilateral flap from the cutaneous canal and carrying it into the antrum.

From a careful study of the Stacke operation, I am not yet convinced of its value. My own experience in the treatment of mild cases of middle-ear suppuration by the removal of the ossicles through the canal, the removal of the floor of the tympanic attic by means of the rongeur forceps, and the thorough curettement of the entire tympanic cavity, including the vault, has led me to believe that where the disease is confined to the middle ear alone, this method of procedure is eminently satisfactory. Out of ninety-two cases upon which I have operated by removing the ossicles and curetting the tympanic cavity, fifty-three were cured, twenty-five improved, two unimproved, and in twelve the result was unknown. Schroeder * reports one hundred and thirty cases of extraction of malleus and incus for middle-ear suppuration. Out of this number sixty-two were cured, thirty-nine were not cured, and in twenty-eight the result was unknown.

I confess that by personal experience this operation has been limited to a few cases. These possibly may not have been well selected, although considerable care was exercised in their selection. My own belief is that where a posterior incision is necessary, in order to remove carious bone from the tympanum, the operator should not be content to expose the tympanic vault and *aditus ad antrum* alone, as these parts can be equally well exposed through the natural channel. When, therefore, any doubt exists as to the extent of the suppurative process, it has always been my practice to do the complete Stacke-Schwartze operation—that is, to enter the mastoid antrum in the usual way, and to throw this cell and the vault of the tympanum into one large cavity communicating directly with the external meatus. This operation is fully described on a subsequent page, under the head of the Stacke-Schwartze Operation.

Stapedectomy.—(*a*) *When the membrana tympani is intact.* The incudo-stapedial articulation is exposed either by a curved incision in the postero-superior quadrant close to the attachment of the membrane to the tympanic ring, or by a triangular incision in this situation, or by the incision already described in the operation of exploratory myringotomy. After the incudo-stapedial articulation is brought into view the stapedius muscle should be completely divided; the incudo-stapedial articulation is then severed and the long arm of the incus pushed forward so as not to interfere with the subsequent steps. If the presence of the incus still interferes with the separation of the stapes the long process may be seized with the forceps and the ossicle removed. The stapes is then freed, by means of the sharp straight knife, from adhesions binding it to the oval niche, and is removed by gentle traction with the forceps or by a hook passed between the crura. It is important to sever the stapedius muscle completely before disarticulation, as otherwise, after separation from the incus, the stapes may be pulled out of view. If the foot plate is found anchylosed this condition may be treated in the manner already suggested, although in such a case, as the parts would be subjected to more violence, it is probable that removal of the malleus, incus, and membrana tympani would diminish the chances of reaction after the operation.

---

* Archiv für Ohrenheilkunde, vol. xlix, p. 17.

After the first incision through the membrana tympani, the direct application of the cocaine solution to the middle ear by means of a cotton-tipped probe renders the subsequent steps painless. In three cases of this kind I have been able to clear the oval niche in the above manner, no pain being experienced after the first incision through the membrana. If a very sharp knife is used this is never severe. After this no pain need be felt if cocaine is carefully applied. My results have been fairly satisfactory; but I am inclined at present to confine the procedure to cases where the condition has resulted from a suppurative inflammation, and in non-suppurative cases to mobilize the stapes instead of removing it. In these cases, if mobilization improves the hearing, I also prefer to remove the malleus and incus, thus leaving the stapes accessible in case a second mobilization becomes necessary.

After removal of the stapes the flap may be replaced and held in position by a paper dressing. The meatus is occluded by a plug of antiseptic cotton, which is left in position for several days unless inflammatory symptoms supervene. The wound usually heals in a few days, and in no case has the reaction been severe.

(*b*) *When the membrane is partially destroyed* the stapes or the incudo-stapedial articulation may be already in view; but if neither is visible, the appropriate incision for the exposure of these parts will vary in each case, after which the technique previously given is to be carried out. In two cases operated upon under local anæsthesia, the stapes being clearly in view, extraction was easily accomplished and the results were flattering, in one instance the hearing for a low whisper increasing from seven to thirty feet. Here the entire stapes was removed intact. In the second case only a portion of the ossicle was secured and removed, yet the improvement was considerable. It is well to bear in mind that even slight hæmorrhage will render the removal of the stapes difficult; and when this region is covered by dense structures, which bleed freely when incised, it may be necessary to remove the malleus and incus and remains of the membrane to secure a suitable field for the performance of stapedectomy.

The after-treatment may be the same as in the preceding class of cases. It is well, however, to inspect the ear at the end of twenty-four hours, and, if signs of inflammation are present, to cleanse it frequently with a mild antiseptic solution. If, however, the parts are perfectly dry, they should not be disturbed, for fear of interfering with the healing process.

From personal experience, the author believes that at the present time a lesion of the conducting mechanism resulting from a non-suppurative inflammation which demands operative interference will be more satisfactorily combated by the removal of the membrana tympani, malleus, and incus, and mobilization of the stapes, than by other operative measures. In residual purulent cases mobilization of the stapes will usually yield results as good as those obtained by stapedectomy. The advantage of removing the two larger ossicles in both classes of cases lies in the fact that the stapes is thus left exposed, and can be repeatedly mobilized if necessary. When the ossicle is mobilized or removed, and the flap of drum membrane is allowed to resume its former position, the beneficial results are often but temporary, and disappear when the opening in the membrana closes.

When operations are performed for improvement of function they may always be conducted under local anæsthesia, and the improvement or failure to improve may be noted at each successive step. The operation can therefore be discontinued at any stage, if the operator judges that he is not warranted in proceeding.

The results of my operations were reported * a few years since, and the compilation which follows includes a few additional cases.

Of cases where the membrana tympani was intact, including one or two instances where there had been a suppurative process in childhood, with complete closure of the perforation, ninety have been subjected to operation. Of these, there was much improvement in seventy-eight cases, ten were unimproved, one grew worse after the operation, and in one the re-

---

* Transactions of the American Otological Society, 1894.

sult was unknown. Thirteen of these cases were operated upon under ether. Of these, two were greatly improved, five much improved, five slightly improved, and in the remaining case the condition remained the same as before operation.

In eleven cases the condition was due to a previous purulent inflammation, which had resulted either in a slight or extensive destruction of the membrana tympani, the perforation persisting. The operative procedures were confined to freeing the stapes and mobilizing it, as described in the preceding pages, without resort to general anæsthesia. Of these, there was great improvement in one, the whispering distance increasing from twelve inches before to fifteen feet after operation, and the degree of improvement being maintained at the time of the last examination, which was about six weeks after operation. In ten there was decided improvement, although not as great as in the case just mentioned. Of the eleven cases, disagreeable symptoms followed the operation in but one instance.

In ten cases there was a purulent otitis, in which the operation was performed both for the relief of the otorrhœa and at the same time to improve the hearing. Of these, there was great improvement in five, moderate improvement in three, while in two the function of the organ remained the same as before operation.

In ten cases the membrana was intact and the stapes was removed, or the crura fractured in the attempt at removal, the operation being done with cocaine. In most instances removal of the incus was necessary in order to gain access to the stapes. Of the ten cases, three were improved, two were much improved, one slightly improved, two unimproved, and two were made worse. In one case, where much improvement followed the operation, a relapse took place at a later period, although the hearing still remained better than before the operation.

In quite a number of these cases of stapedectomy it was found that the improvement became much less after the perforation in the membrana tympani closed, and in these instances the malleus and membrana tympani were removed at a later period, in order to secure a permanent opening into the tympanic cavity. This procedure was followed by improvement in all the cases. In one instance synechiotomy was practiced for the improvement of hearing before the purulent discharge had ceased entirely, this being so moderate in amount as scarcely to warrant general anæsthesia and the removal of the entire ossicular chain. Slight improvement followed the procedure in this instance.

It will be seen from these statistics that the greatest improvement has followed those operations performed under cocaine anæsthesia, and where the design has been to secure a permanent opening into the tympanum. This seems to be the most rational procedure in all cases where the membrana tympani is intact; and since it can be done without general anæsthesia, we are certainly warranted in recommending at least an exploratory tympanotomy in all cases where the hearing has failed to improve under less radical measures. In no given case can we state the amount of improvement which we should expect, and it is always our duty to inform the patient of the experimental character of the measure. From the fact, however, that the procedure is followed by no discomfort, that it can be performed without pain, and that, humanly speaking, it will not injure the organ, we certainly fail to fulfill our entire duty to the patients if the subject is not presented to them fairly.

CHAPTER XXVIII.

THE MASTOID OPERATION.

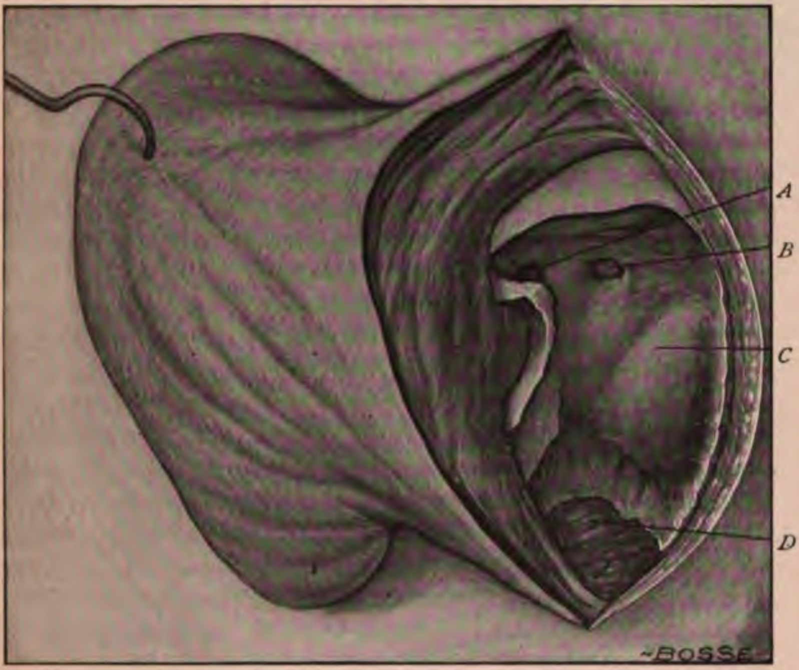
THE instruments required for this operation are shown in Plate XII. While all of these instruments may not be necessary in each case, experience teaches that the more complete the armamentarium, the better and more rapidly can the work be accomplished.

The ear should be first thoroughly cleansed by syringing with 1-to-1,000 bichloride solution, or with a dilute (1 to 10) solution of peroxide of hydrogen, after which the meatus is thoroughly tamponed with iodoform gauze. The scalp should be shaved over an area extending in every direction for a distance of three inches from the meatus, and if the patient has a beard it should also be removed. The skin is then scrubbed, first with soap and water and then with ether and alcohol, and finally with a solution of bichloride of mercury (1 to 1,000), or a two-and-a-half-per-cent solution of carbolic acid. A wet bichloride dressing is then applied over the entire field of operation and allowed to remain until the patient is anæsthetized. When possible, this preparation of the field should be made at least four or five hours before the time of operation.

After the induction of anæsthesia the antiseptic dressing is removed, the tampon within the canal is changed, and the integument washed again with ether, and irrigated subsequently with a bichloride solution (1 to 2,000). The parts surrounding the field should be covered either with sterile towels, or with towels moistened in 1-to-1,000 bichloride solution. All instruments are to be sterilized by boiling, and the hands of the operator and his assistants should receive the ordinary attention demanded in all surgical operations.

It may seem unnecessary to take all these precautions in a procedure apparently so simple; but when we remember that, owing to an anomalous position of the parts, or to the destruction resulting from the inflammation, we may either enter the

PLATE IX



THE COMPLETE MASTOID OPERATION.

The plate shows the complete mastoid operation, with the obliteration of all of the mastoid cells. *A* is the *aditus ad antrum*. *C* the bony covering of the lateral sinus. *D* is the digastric muscle. *B* is a small cell sometimes found just behind the prominence of the horizontal semicircular canal. Note the prominence of the horizontal semicircular canal between *A*, the *aditus ad antrum*, and *B*, a deep cell sometimes found in this region. The posterior osseous wall of the external auditory meatus is also well shown. In front of *A* the bone has been removed, so as to explore the zygomatic cells. (Author's dissection.)

cranial cavity accidentally or feel compelled to do so as a matter of election, we should never undertake the procedure without being thoroughly prepared to extend our operation in this direction if necessary. The primary incision begins over the middle of the mastoid insertion of the sterno-cleido-mastoid muscle, about half an inch below the tip of the mastoid process, and is carried upward and forward close to the line of insertion of the auricle, after which it follows this line to a point directly about the meatus (See Plate XI).

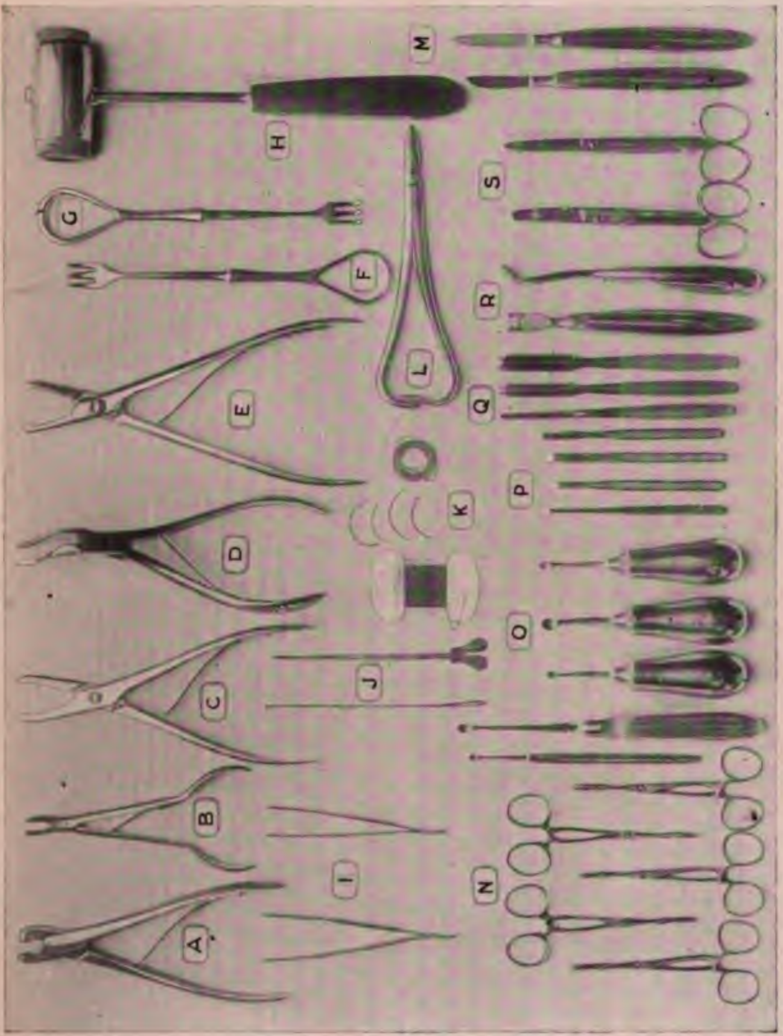
Particular attention should be given to the location of this incision, as ordinarily the line of section lies so far back that when the flaps are retracted the posterior and superior walls of the canal are not freely exposed. In addition to this, the free vascular supply of anterior flap causes it to become œdematous almost immediately, thus increasing the difficulty with which it is drawn forward, rendering a perfect exposure of the parts impossible. If the line of incision is made so close to the auricular insertion as to admit of the introduction of a line of sutures only, the field of operation will be much better exposed, while subsequent deformity will be prevented, the cicatrix being concealed completely by the auricle, which resumes an absolutely normal position. The soft parts should be divided to the bone throughout the entire extent of the incision. All bleeding points should be secured with clamps.

The next step of the operation is elevating the periosteum. The entire anterior flap is pushed forward by means of an elevator carried beneath the periosteum, raising this and the overlying muscular structures from the bone, the parts being pushed forward until the posterior and superior margins of the bony canal are plainly in view. The posterior flap is elevated in a similar manner. All bleeding points are now caught by means of clamps. The auricle is held forward by a retractor, the instrument being intrusted to the hands of the assistant. The upper part of the incision is filled with gauze sponges, in order that all oozing may be controlled, while the operator directs his attention to clearing the aponeurosis of the sterno-mastoid muscle from the tip of the process.

This is best done with blunt scissors curved on the flat, which can be closely applied to the bony surface and made to divide the dense fibrous tissue by successive short cuts. Care must be taken to hug the bone closely, otherwise the large vessels of the neck may be injured. This separation of the muscle should be continued until the finger can be passed completely around the tip of the mastoid, and if the primary incision has not been made low enough to allow this, it must be extended. The packing is now removed from the upper part of the wound and the exposed area is examined for the presence of any sinus, the result of spontaneous rupture. If this is found, it is enlarged either by the curette or gouge, the surgeon following the channel which has been thus established, and which will be found in all cases to communicate either directly or indirectly with the mastoid antrum. If no sinus is present, the first step in every case is to enter the antrum. We remember the location of this to be just behind the posterior margin of the meatus and just below its superior margin. Until we have gained entrance to this cavity our opening through the cortex should never extend above the superior wall of the canal, thus avoiding the middle cranial fossa, while we should keep close to the posterior wall on account of a possible malposition of the lateral sinus.

The cortex is best removed by means of the chisel or gouge (Plate XII, P and Q) and mallet, a large cutting instrument being used at first and changed for a smaller one as the wound is deepened. The chisel is applied nearly parallel to the surface of the skull, and made to cut away the bone in thin, broad chips, the cutting edge being directed downward and forward. In this way we form a bony funnel, the base of which may be broadened posteriorly and below, if necessary, but never above. The apex of the cone should always lie within the triangle which marks the entrance to the antrum. Where the pneumatic spaces are superficial they may be opened with the first blow of the mallet, after which it is wise to lay aside the chisel and continue the operation by means of the sharp spoon (Plate XII, O), breaking down the walls of the air spaces until the mastoid antrum is entered. This never lies less than half an inch below the surface, although we may encounter large pneumatic spaces more superficially. We recognize that the antrum is entered by the fact that a probe, slightly curved at the tip, after entering the artificial opening, passes downward, forward, and inward for a distance of from three quarters to seven eighths of an inch, at which depth it enters a cavity of considerable size; in other words, it has passed into the middle ear. We persist in our efforts at entering this cavity, although pus may have been

PLATE X



INSTRUMENTS FOR MASTOID OPERATION.

A, B, C, D, E, Rongeur forceps, various sizes; F, G, retractors; H, mallet; I, dissecting forceps; J, probe and director; K, needles, silk, and catgut; L, needle-holder; M, scalpels; N, artery clamps; O, sharp spoons; P, straight chisels; Q, gouges; R, periosteum elevators; S, straight scissors, curved and flat.

evacuated previously. The passage between the antrum and the tympanum should next be curetted freely by means of a delicate sharp spoon (Fig. 123, *a*). This portion of the tract is invariably occluded by granulation tissue, while its bony walls are often carious.

The next step is to thoroughly obliterate the entire pneumatic structure of the mastoid process. The remaining cortex is removed with the chisel, curette, or rongeur, as may be most convenient. The large cell at the apex must be particularly investigated, opened freely, and the tip of the mastoid process should be removed with the rongeur forceps. The operation should be continued until sound bone is encountered in every direction. In some cases, the destruction of bone will be found to be so extensive as to prevent the removal of all diseased tissue through the single linear incision already advised. A second incision is then made from the middle of the linear incision, extending horizontally backward for a distance of one inch to an inch and a half. The bleeding points are secured by means of clamps and the underlying bone is uncovered by means of the periosteum elevator. The mastoid emissary vein may be wounded in elevating the periosteum, and quite free hæmorrhage occur. This hæmorrhage is easily controlled by means of a folded strip of iodoform gauze placed over the vessel. This is held in position by an assistant, while the operator proceeds to remove all softened bone. If the inner table is affected, we should not hesitate to remove it, as an exposure of the dura under proper precautions is a matter of no importance, while to leave carious bone in contact with this, is a grave error. Exposure of the lateral sinus, either accidentally or intentionally, in no way complicates the operation. If the vessel is opened, sharp hæmorrhage results, and herein lies the advantage of extensively removing the cortex. If the wounded vessel lies at the bottom of a deep, narrow, bony channel, the hæmorrhage may be controlled; but it is difficult to proceed with the operation, and the purpose for which it was instituted will therefore not be carried out. With a free removal of the cortex the bleeding point lies plainly in view, and the hæmorrhage is easily controlled by a firm compress of iodoform gauze. This is held by an assistant, and the surgeon finishes the operation as though nothing untoward had happened. Hæmorrhage from the sinus is no more severe than that from one of the large venous trunks of the upper extremity, and the possible untoward results which may follow a wound of this vessel will depend upon the imperfect exposure of the bleeding point rather than upon the loss of blood or the accidental infection through the sinus.

Having now removed all softened bone and ligated all bleeding vessels, the management of the wound will vary according to circumstances. If no sinus or dura has been exposed and we have a simple mastoid wound, the best procedure is to first insert a strip of iodoform gauze packing into the antrum and bring it out at the lower end of the wound. The periosteum is then sutured by a continuous suture of fine catgut from the upper angle of the wound throughout two-thirds of its extent. The superficial wound is then closed either with Michel clips or with interrupted sutures of either silk or silkworm gut. Only the lower angle of the wound through which the packing protrudes remains open. With exposure of dura or sinus this partial closure is modified as indicated below. If it has been necessary to make the posterior horizontal incision, this should be closed by means of silkworm-gut sutures. In cases where the mastoid emissary vein has been wounded and there has been considerable hæmorrhage, a small pledget of gauze may be placed over the foramen through which the vein passes, the end brought into the mastoid wound, and the horizontal incision sutured over this packing. It is not necessary to pack the external wound, as was formerly done, and the omission certainly renders the first dressing more comfortable. The dressing is completed by covering both the wound and the ear with several layers of dry sterilized gauze and cotton, the whole being confined in place by a bandage.

In cases where the lateral sinus has either been exposed or wounded, or where the dura in the middle cranial fossa has been exposed, these areas should be isolated from the remainder of the mastoid wound by a separate gauze packing. My own procedure in these cases is as follows: After all softened bone has been removed, a strip of iodoform gauze is carried into the *aditus ad antrum*. The strip of gauze is then intrusted to an assistant and a second strip is packed over the exposed lateral sinus, so as to wall this off from the remainder of the operation cavity. Any exposed dural area is treated in a similar manner. The strip of gauze, one end of which has been carried into the antrum, is now packed into the mastoid cavity, and those strips of gauze which have been used to isolate the sinus and exposed dura from the remainder of the wound are subsequently packed in about this. In this manner, we wall off, so to speak, the cranial cavity from the remainder of the wound and from that part of the wound which is infected, by a firm layer of iodoform gauze. I believe that, in many instances, this method of dressing the case at the time of operation has prevented the subsequent involvement either of the meninges or of the sinus.

n cases where the technique has been perfect it is not necessary to remove the dressing under two or three days. The necessity of changing the dressing at an early period will be indicated by a rise in temperature or by local pain. Where the temperature does not exceed 101° at any time during the first three days, or, if elevated, is not persistent, the dressing need not be changed.

The subsequent treatment is simple. At the first dressing we frequently find the canal absolutely free from discharge. If considerable secretion is present it is wise to irrigate the parts freely, the fluid employed being introduced through the artificial opening and allowed to pass out of the meatus; the technique of the dressing is the same as at the time of operation. Where the lateral sinus has been opened, or the dura exposed in any other location, particular care is necessary at each dressing to guard against local infection, the exposed dural area being uncovered first, cleansed and protected with a gauze pad, after which the packing may be removed from the mastoid portion of the wound and the dressing done as above directed.

After the first dressing it will be usually necessary to dress the case daily. As the wound heals, exuberant granulations may appear, and these must be treated in the ordinary manner. If the granulations proliferate too rapidly, sterile gauze instead of iodoform gauze may be used. If this change in dressing does not control the granulations, it is wise to cut down the exuberant tissue with scissors and then touch the cut surface with a solid stick of nitrate of silver. Where the destruction of bone has been very extensive, we sometimes find that the opening in the bone fills up very slowly. Here stimulation of the granulating surface with nitrate of silver will hasten the reparative process. Where the granulations are sluggish, instead of packing the wound with plain gauze, the use of sterile balsam Peru gauze will frequently cause the wound to heal more rapidly. In some of these cases, where the reparative process is slow, the mere scraping of the granulations with a dull curette, allowing the bony cavity to fill with blood, and then applying a sterile gauze dressing, has been found efficacious in hastening the healing of the wound.

These suggestions may be of value in the after-treatment. Each individual case, however, must be managed according to the indications, and suggestions as to the conduct of the after-treatment must be followed only in the most general way.

In addition to wounding the sinus, the operator may occasionally expose or even wound the dura in the middle cranial fossa. Entering the cranial cavity at this point can be avoided in every instance if the cortex is not removed above the level of the superior wall of the canal. When the temporal ridge is very prominent and the margin of the meatus is placed so far below this as to render adherence to this rule almost impossible, the operator may deem it wise to extend the opening in the bone slightly above the line indicated. Exposure of the dura in this region is a matter of no great consequence, and is sometimes necessary in order to remove all diseased bone. If a small area is exposed either accidentally or in the removal of diseased bone, it is well to increase the size of the opening until the dura is exposed over a space of at least three-quarters of an inch in diameter. A large exposure of dura is almost never followed by general meningitis, while meningitis does occasionally follow the exposure of a small area. Where the dura is wounded, the dura should be freely exposed so as to lay bare the opening. The rent in the dura should be protected with a pad of gauze until the operation is completed. The dural wound may be treated either by suture, which is probably the least advisable, by carrying a strip of gauze down to the dural opening so as to cause the obliteration of the subdural space and prevent infection of the brain tissue, or, if the injury has been such as to render infection of the brain substance probable as the result of manipulation, the opening in the dura should be enlarged by two crossed incisions and the subdural space walled off with iodoform gauze packing.

Because the squamous plate of the temporal bone is more horizontal in infancy, and because of the manner in which the fibrous canal is applied to the outer surface of the squama on account of the absence of the bony canal at birth, attention should be given to certain variations which must be practiced when the mastoid of a very young child is to be operated upon. At birth, since the fibro-cartilaginous meatus along its superior aspect is applied to the external surface of the squama, the line of attachment of the auricle to the skull lies at a much higher level than does the membrana tympani, and the superior extremity of an incision along the line of auricular attachment would lie at a much higher level than the upper border of the tympanic ring (Fig. 122). The relative position of the parts at the line of auricular attachment is misleading, since, when the anterior flap is pulled forward, the fibro-cartilaginous tube constituting the meatus is attached so firmly above and behind as to frequently mislead the operator and cause him to think that the margin of the annulus has been exposed. If the bone is perforated without exposing the posterior limb of the annulus clearly, and making out the exact situation of the prominent posterior tubercle, both by touch and by inspection, the operator may accidentally open the middle cranial fossa instead of the pneumatic space of the mastoid and middle ear. The superior and posterior attachments of the meatus should be separated carefully from the squama after the primary incision until the posterior tympanic tubercle is reached and the canal merges into the drum membrane. It is often well to incise the fibrous tube transversely for a short distance, in order that a clear view may be obtained of the membrana tympani and render an error impossible. If the bony cavity is entered just behind this tubercle and close to it, the antrum will be opened, after which it will be easy to chip away the external table for a considerable distance forward and upward, thus exposing the tympanic vault (Fig. 122). It is wise, however, to make it a rule to never remove the outer layer of bone at a higher level than the posterior tympanic tubercle as a primary procedure. The depth of the middle cranial fossa varies considerably in different subjects, but always lies above the point named. The exact conformation of the parts in any individual case is easily made out when access is once gained to the pneumatic spaces, after which the operator will adapt his operation to the anatomical conditions present. The external wall of the tympanic vault at birth occupies in reality the position of its inferior wall in adult life, owing to the change in direction taken by the squamous plate as development progresses. The vault will therefore be entered with very little trouble close above the line of attachment of the membrana superiorly. Another word of caution is also proper regarding the initial incision. Since the mastoid squamous suture is not ossified at birth, and frequently presents large dehiscences filled by fibrocartilage, the knife, in making the initial incision, should not be pressed with any force upon the bone, but the soft parts should be divided slowly until the bone is exposed throughout the line of incision. Firm pressure upon the scalpel might easily result in plunging it into one of these dehiscences, causing it to enter the cranial cavity. The utmost gentleness should also be observed in dissecting up the periosteum and turning the anterior flap forward, for the same reason.

In every instance, then, either in adults or in children, no procedure should be instituted for the removal of osseous tissue until the posterior and superior margins of the bony canal are not only accessible to the finger but plainly in view, and the soft parts should be so retracted that the landmarks may be always under the eye of the surgeon throughout the entire operation.

The facial nerve as it crosses the tympanic cavity is occasionally wounded in cases of sclerosis where the bone has been removed to a sufficient depth to expose the internal wall of the middle ear. The aquæductus Fallopii lies within the middle ear, and consequently it is impossible to wound it until the operation is really completed and free communication established with the tympanum. It is wise, after perforating the bone to a depth of seven eighths of an inch, or perhaps a little less, to pass a probe bent at a right angle into the external auditory meatus, and carry the angular portion upward and backward into the tympanic vault, in which position it is to be held. The operator then has only to continue the removal of bone until the artificial opening exposes this probe within the tympanum. A wound to the external semicircular canal is more unlikely to occur than one of the facial nerve. The canal lies immediately above the aqueduct, and can only be injured when the opening is made exceedingly high. When in any doubt as to the advisability of perforating more deeply on account of the possibility of injuring either of these structures, the plan usually followed is to remove that portion of the posterior wall of the canal lying immediately in front of the artificial opening. The canal must lead into the middle ear, and the removal of this bony partition until the tympanum is reached renders the completion of the procedure absolutely safe. In these cases that portion of the bony posterior wall at the inner extremity of the canal, made up of compact osseous tissue, should be left, since it is possible to wound the facial nerve under these conditions if the entire posterior wall is removed. Slight injury to the facial nerve is not a serious accident, function being restored in from three to five weeks, in most cases, under the use of the faradic current.

In certain cases where the destruction of the osseous tissues has been very extensive, and where during the period of convalescence sequestra separate from the bony walls, a permanent opening will remain behind the ear. This has occurred six times in over four hundred operations. Various methods have been devised for closing these openings, among which is one advocated by Trautmann.* This consists in circumscribing the entire opening by means of an incision extending simply through the skin. Two semilunar flaps will thus be formed, one before and one behind. These two flaps are dissected up from over the underlying tissues and turned into the opening. Their raw edges are united in the median line by means of sutures either of catgut, which will easily be absorbed, or by means of silk sutures, the sutures

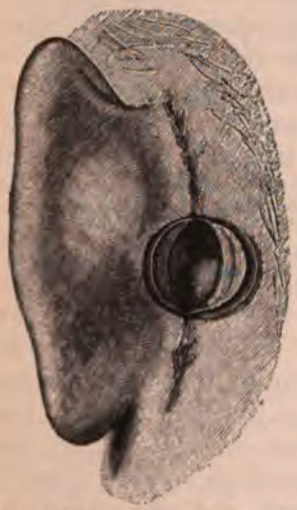


FIG. 141.—Plastic operation for closure of opening behind the ear, as advised by Trautmann.

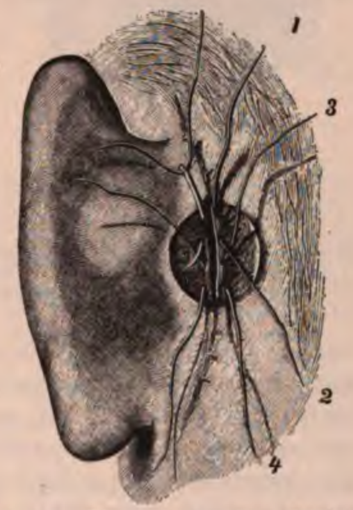


FIG. 142.—The same operation, showing manner of passing sutures.

---

* Operationen am Gehörorgan, Berlin, 1901, p. 80.

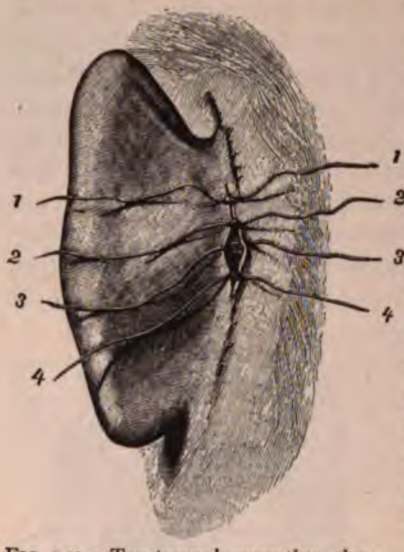


FIG. 143.—Trautmann's operation, showing deep sutures tied and superficial wound closed with interrupted sutures.

being so passed that when tied the knots will lie within the external auditory meatus. The raw surface of these flaps is then covered by dissecting up the integument anteriorly and posteriorly and drawing this together over the flaps thus formed, the superficial sliding flaps being sutured in the median line, thus covering perfectly the raw surface, and effectually closing the fistula. When the fistula is closed in this manner, it will be easily seen that the meatus is completely lined with epidermis throughout, the cutaneous surface of the internal flaps or those first formed being turned into the meatus. The opening behind the ear is entirely obliterated and covered by skin owing to the approximation of the sliding skin flaps which cover completely the internal flaps first formed. The only fault to be found with this method is that, owing to the fact that the posterior opening in these cases is lined with cicatricial tissue, the nutrition of the flaps is exceedingly poor. The flaps are, therefore, very liable to slough, and the operation to prove a failure. A more satisfactory method of closing these openings is that of Mosetig-Moorhof.* For this method a tongue-shaped flap is cut from the integument immediately below the opening to be closed. This flap is dissected up from below and on the sides, being allowed to remain attached superiorly to the inferior margin of the perforation to be closed. The flap should be considerably larger than the opening which it is required to fill in order to allow for subsequent contraction. After this flap has been dissected up the margins of the opening are denuded by means of the scalpel, the skin about the margins of the perforation being dissected away from the underlying tissues behind, above, and in front. The tongue-shaped flap is then turned into the opening to be closed, and held in place by catgut sutures. The integument in front and behind the opening into which this flap is turned is then also dissected up, the dissection being carried downward along the margins of the denuded area from which the flap was taken. In this way, two sliding skin flaps are formed, one in front and the other behind, which upon being approximated will completely cover the tongue-shaped flap which fills the opening behind the ear, as well as the denuded area from which this tongue-shaped flap was taken. These sliding flaps are approximated and held in position by either silk or silkworm-gut sutures. I have employed this method in closing openings of this character; although union by first intention may not take place throughout the entire extent of the wound on account of the fact that the flaps are formed almost entirely of cicatricial tissue, the procedure is effectual in completely closing the perforation. Although portions of the flap may slough, the resulting wound heals readily by granulation, and the result of the operation seems to be good in every instance.

---

* Centralblatt für Chirurgie, 1898, No. 46.

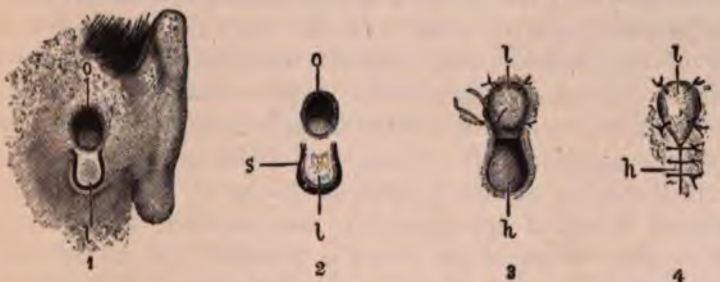


FIG. 144.—Mosetig-Moorhof's operation for closure of retro-auricular fistula. No. 1, *l*, Tongue-shaped flap cut from tissues of neck; No. 2 shows this tegumentary flap elevated and margins of the retro-auricular opening (*o*) denuded; No. 3, *l*, Flap sutured in position; *h*, Denuded area left where flap is dissected up; No. 4, External wound closed by sutures (*h*) after undermining edges of wound. This undermining should be continued about the fistulous opening as well, so that when the superficial wound is sutured, the raw surface of the flap will be completely covered by integument. This is not shown in the figure.

Quite recently Frey * has reported a number of cases in which the deformity following an extensive mastoid operation has been entirely relieved by the subcutaneous injection of paraffin. This method has been used not only to fill up the retro-auricular depression, so frequently found in these cases, but also to actually fill up any permanent opening behind the ear, which may have been left as the result of the operation. In cases where a post-aural fistula of considerable size is present, the method consists in making a subcutaneous injection into the tissues forming the anterior —that is, the auricular margin of the fistula. These tissues are exceedingly soft, and a sufficient amount of paraffin can be injected into the anterior flap to cause this to cover over the post-auricular opening. In this way the cutaneous surface of the anterior and posterior margins of the fistula are brought into close apposition. A few weeks after the tissue has been injected, the cutaneous edges of the anterior and posterior margins of the hiatus, which are now in apposition, are freshened by means of a scalpel or scissors. These two fresh surfaces, lying in apposition to one another, soon become united, the closure of the fistula is complete and all deformity overcome. The mixture to be injected consists of about equal parts of the best paraffin and liquid vaseline. The paraffin is melted in an ordinary enameled or porcelain casserole and liquid vaseline added. After the mixture has been heated for about ten minutes, to thoroughly sterilize it, a glass rod is dipped into the mixture and a drop of the fluid allowed to fall upon the hand. As soon as this drop touches the skin, if it becomes of the consistency of a rather thick ointment, the amount of solid paraffin and liquid vaseline is in the right proportion, and the injection is proceeded with. If, on the other hand, as soon as the drop strikes the cutaneous surface it becomes solidified, a little more liquid vaseline must be added before injection, to make the mixture slightly more fluid; or if, when the drop falls upon the hand, it still retains its fluidity, the mixture is not quite thick enough for injection, and a little more paraffin must be added. Experimentation will enable the operator to make the mixture of the right consistency.

---

* Archiv für Ohrenheilkunde, vol. lvi, p. 289.

The technique of injection does not differ from that of paraffin injection in other parts of the body. An ordinary exploring syringe, with a metal barrel and with either an asbestos or metal piston, should be used, so that the instrument can be thoroughly sterilized beforehand. After the syringe and the needle, which should not be too large, have been sterilized, the syringe is filled with the liquid paraffin, and placed in a bath of hot water to keep the mixture liquid until its injection. When all is ready, the tip of the syringe is made to pierce the integument either from below upward or from above downward, and is carried some little distance subcutaneously. The fluid is gradually injected by the operator, while an assistant molds the parts into proper shape. It is frequently necessary to introduce the needle two or three times before the deformity is completely overcome.

This method will certainly be efficient in relieving deformity of this kind in certain instances. While the plastic operations previously described effect a radical cure of the deformity, it must be remembered that in some cases the cicatricial tissue is so extensive as to rather militate against success. It is in just this class of cases that this method is of particular value.

CHAPTER XXIX.

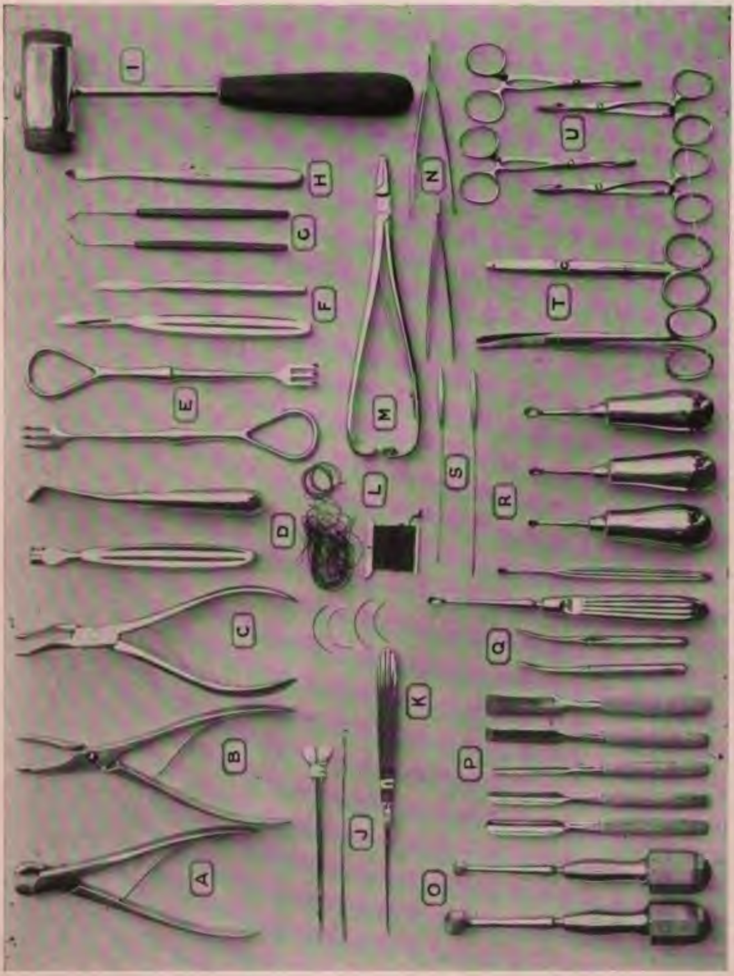
RADICAL OPERATION FOR CHRONIC OTORRHŒA.—STACKE-SCHWARTZE OPERATION.

In cases of chronic suppuration, where there is evidently an involvement of the adjacent pneumatic spaces within the mastoid, no operation either upon the middle ear or mastoid alone will be sufficient to cause entire cessation of the discharge from the middle ear, or, in case mastoid symptoms are present, to afford complete relief. Furthermore, it must be remembered that in cases of chronic suppuration of the middle ear, with extension to the mastoid process, there is always danger of infection of the adjacent intracranial structures unless the purulent focus is completely eradicated. Those cases of suppurative otitis media of long standing, in which there has been a deposit of cholesteatomatous material within the tympanic vault and in the mastoid cells, are particularly prone to be complicated by an invasion of the intracrānial structures. For this reason the surgeon should always perform so thorough an operation as to remove every possible source of infection from the entire middle-ear tract, and secure such thorough drainage as to render an extension of the suppurative process inward absolutely impossible.

Operative procedures have been instituted with this end in view; in all of these the absolute necessity of free drainage, both of the middle ear and mastoid antrum, is recognized.

Küster was one of the first to establish through and through drainage between the mastoid cells and the external auditory canal. This procedure, however, simply established a very fair drainage between the external canal and the mastoid cells, the tympanic vault having apparently been completely overlooked by the surgeon. To obviate this defect, Bergmann conceived the plan of thoroughly draining the tympanic vault by removing its inferior and posterior wall. The operation

PLATE XI



INSTRUMENTS FOR RADICAL OPERATION.

A, Large rongeur forceps; B, small rongeur forceps; C, Jansen rongeur forceps for enlarging *aditus*; D, periosteum elevators; E, retractors; F, scalpels; G, Stacke's angular knives; H, narrow blunt dissector for separating fibrous meatus; I, mallet; J, grooved director and probe; K, Riverdin needle; L, curved needles, silk, silkworm-gut and catgut, the latter used both for sutures and ligatures; M, needle-holder; N, dissecting forceps; O, burrs for smoothing bony cavity, prior to grafting; P, large and small chisels and gouges; Q, curved gouges for removal of external wall of attic; R, sharp spoons of various sizes; S, cotton-holders; T, blunt scissors, curved and straight; U, artery clamps.

proposed by Bergmann has been somewhat elaborated by Stacke,* who has obtained excellent results by this method.

The combination of the methods of Küster, Bergmann, and Stacke constitutes, with some slight modifications, the operative procedure employed at the present time by most otologists in dealing with these cases, and is known as the Stacke-Schwartze operation. The technique of the procedure is as follows: An incision is made extending from just below the tip of the mastoid and following the curvilinear line of auricular insertion about one third of an inch behind this line to a point just above the superior attachment of the auricle. The incision is carried through all of the soft parts down to the bone. In making this incision, operators vary as to the distance at which it should be placed behind the line of auricular attachment. Thus, Ballance † places the incision at least one half of an inch behind the posterior auricular fold. This operator also carries the first incision through the integument alone, the deeper structures being divided more anteriorly. In this way the posterior wound is terraced, so to speak, the line of division of the deeper tissues being anterior to that of the superficial cutaneous tissue. I have employed this incision, but find that it possesses no advantages over the more simple method of carrying the initial incision through the soft parts down to the bone. It is important in dividing the superficial structures, to carry the incision well forward over the top of the ear. If this is not done, it is almost impossible to secure a perfect exposure of the superior wall of the canal, and it is therefore difficult to thoroughly remove the external wall of the tympanic vault. In carrying the incision over the ear, it is not necessary to divide all the soft tissues down to the bone. If the skin and superficial fascia are divided in this locality, it will be perfectly possible to thoroughly expose the upper wall of the canal by strong traction on the flap without dividing the underlying fibres of the temporal muscle. All bleeding vessels are secured by clamps, care being taken to bruise the soft tissues as little as possible. All of the soft parts composing the anterior flap are separated from the underlying bone by the use of the periosteum elevator. In this way the auricle is turned forward and the margins of the bony meatus become visible. The fibro-cartilaginous lining of the bony meatus is now carefully separated from the osseous walls by means of a narrow, blunt-pointed periosteum elevator, or, if this instrument is not at hand, the closed blades of the blunt-pointed scissors, curved on the flat, may be used for this purpose. The fibro-cartilaginous tube is dissected from the upper, posterior, and inferior walls to as great a depth as possible. In cases of profuse suppuration, of long standing, it will be impossible to separate the soft lining of the canal from the underlying bony parts for any considerable distance. In cases where there has been but slight discharge, however, the surgeon can frequently carry this dissection to within a short distance of the drum membrane before the lumen of the cartilaginous canal is opened by the instrument. When this dissection has been carried as deeply as is practicable, the fibro-cartilaginous tube is divided transversely, as close to the drum membrane as possible by means of a narrow knife. A strip of gauze is then introduced into the external auditory meatus and brought out through the opening behind the ear. Firm traction is now made on this strip and the entire fibro-cartilaginous tube is pulled out of the bony meatus. The posterior flap is now separated from the bone by means of the periosteum elevator, and the typical mastoid operation is performed, the antrum being entered in the manner already described in dealing with the technique of the mastoid operation. The extent to which the mastoid cortex shall be removed and the pneumatic spaces broken down, must vary with each individual case. We not infrequently find, in cases of long-continued suppuration, which have resisted all methods of treatment other than operative, that the mastoid process has become sclerosed, its cellular structure practically obliterated, and that the only pneumatic space which exists is the antrum which, as we know, communicates directly with the middle ear. When this condition is present, it is of course unwise to perform a typical mastoid operation and remove the mastoid tip. This rule applies even when the entire mastoid is pneumatic. We not infrequently meet with cases of chronic suppuration of the middle ear demanding this operation, in which the mastoid antrum alone is involved in the suppurative process. On opening the mastoid cortex, in the usual manner, we find that the mastoid process is pneumatic throughout. It is not necessary in these cases to obliterate the entire pneumatic structure of the mastoid. The operator should proceed carefully and should break down all cells which seem to be diseased. No doubtful tissue should be left. When, however, perfectly normal pneumatic spaces are reached, these need not necessarily be obliterated. The operator must simply look upon this structure as being normal, and may then proceed with the subsequent steps of the operation. Experience has shown that infection in these spaces can be avoided at the time of the operation, and if they are not already diseased they need not be obliterated. As soon as the antrum has been entered, ocular inspection and the careful use of the probe will indicate to the surgeon how much of the mastoid process he must remove. In advanced cases of cholesteatoma we frequently find the entire mastoid converted into a large cavity, filled by a cholesteatomatous mass. In these cases, of course, the cortex must be ablated over the entire affected area so as to remove every vestige of the cholesteatoma. In other cases, we find evidences of purulent infection invading the cells even as far as the tip. In those cases the entire tip must be removed. The extent to which the mastoid is broken down must vary with each individual case, and must be governed by general surgical principles. After the mastoid has been thoroughly cleared out, to whatever extent is necessary, the next step is to break down the bony partition between the external auditory meatus and the artificial opening made in the mastoid. The removal of this bony partition should begin at a level with the upper wall of the meatus, the chisel being directed inward and slightly upward so as to follow the line of the upper wall of the canal.

---

* Die operative Freilegung der Mittelohrräume, Tübingen, 1897.

† Medico-Chirurgical Transactions, vol. lxxxiii.

Instead of breaking down this partition, the operator may follow the plan advised by Stacke,* by first removing the external wall of the tympanic vault through the meatus. The external wall of the tympanic vault, as it will be remembered, is constituted by the upper and inner extremity of the bony canal. The removal of this bony plate exposes the epitympanic space, showing the malleus and incus in position. While it is exceedingly simple in the cadaver to remove the inner extremity of the upper wall of the bony canal through the meatus, and to expose the entire tympanic vault and the *aditus ad antrum* in this way, it is somewhat difficult to carry out this step of the operation when the parts are more or less obscured by blood. The oozing from the cut surfaces quite frequently renders this step of the operation difficult and tedious. I prefer, therefore, to enter the mastoid antrum in the typical manner already described, and to then break down the partition between the artificial mastoid opening and the external auditory meatus. This is best done by dividing the partition first along the horizontal plane parallel with the upper wall of the external auditory canal. If the bony tissues could be divided along this line the *aditus ad antrum* would be reached. If the chisel is carried below this line, there is danger of injuring either the facial nerve or the horizontal semicircular canal. In practice, in order to effect division of the bony tissues along the plane of the upper wall of the external auditory canal, a certain amount of bone must be removed below; consequently, the operator should enlarge the opening through the mastoid cortex until it assumes a funnel-shaped form, the apex of the funnel lying at the mastoid antrum and the broad base of the funnel, including an area of the mastoid cortex and of the external auditory canal, the vertical diameter of which is equal to the vertical diameter of the external auditory meatus. In breaking down the wall between the canal and this funnel-shaped opening in the mastoid, the operator should remove a wedge-shaped piece of bone, the base of the wedge corresponding to the vertical diameter of the meatus and the apex corresponding to the *aditus ad antrum*—that channel which joins the mastoid antrum with the tympanic vault. This removal may be effected either by means of the chisel or the narrow rongeur forceps. The goose-neck forceps, devised by Jansen for this purpose, are very convenient in certain cases.

---

* Die operative Freilegung der Mittelohrräume, Tübingen, 1897.

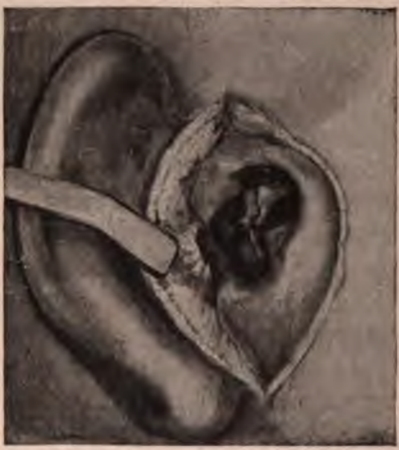


FIG. 145.—The tympanic vault and its contents exposed by the removal of its outer wall, and the division of the fibrous meatus transversely close to the membrana tympani. (Author's specimen.)

The important structures to be avoided lie just below the apex of this wedge-shaped piece of bone to be removed. They are: the horizontal semicircular canal, which forms really the floor of the *aditus ad antrum*, and immediately below this, the aquæductus Fallopii, which contains the trunk of the facial nerve. Lower still we have the oval window containing the stapes. If the operator proceeds from without inward, he may follow the upper wall of the external auditory canal inward until the *aditus ad antrum* is reached. He may follow the inferior wall of the canal inward for at least two thirds of its length. The removal of the bony partition along these lines will then reveal the prominence of the horizontal semicircular canal, and immediately below this, and often amalgamated with it, that of the aquæductus Fallopii. If the posterior wall of the meatus is removed throughout its entire extent as far as the internal wall of the middle ear, either the horizontal semicircular canal or the aquæductus Fallopii must be injured. The point which the operator should remember is to follow inward along the level of the inferior wall of the meatus for about two thirds of the length of this channel, while the bony tissue can be removed along the upper wall until the *aditus ad antrum* is reached. When this triangular or really quadrilateral piece of bone has been removed, the surgeon will be able to see distinctly the prominence of the horizontal semicircular canal and the facial canal, and close inspection will reveal below this the oval window. After these steps of the operation have been accomplished, the operator will then break away the floor of the tympanic vault—that is, the inner extremity of the superior wall of the external auditory meatus. This procedure, when completed, will disclose the entire middle-ear cavity as continuous with the external auditory canal; the head and neck of the malleus with the short and long process will

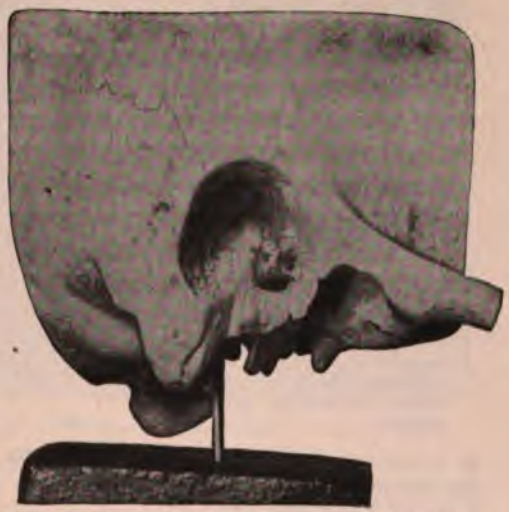


FIG. 146.—Specimen showing appearance of bony cavity after the complete radical operation. (Author's specimen.)

be readily seen, and below this possibly the remnants of the tympanic membrane. The body of the incus, with its short process in the sella incudis and its long process extending downward to the incudo-stapedial articulation, will also be made out. Above the head of the stapes the operator will see the prominent ridge which constitutes the aquæductus Fallopii, and just above this, and often continuous with it, the prominence of the horizontal semicircular canal. It is then simple, after this thorough exposure of the parts, to divide the incudo-stapedial articulation, if this is still intact, and to remove the malleus, incus, and any remnants of the drum membrane. All of this can be done without disturbing the stapes. After the ossicles have been removed, the entire cavity exposed should be curetted until firm bone is encountered in every direction.

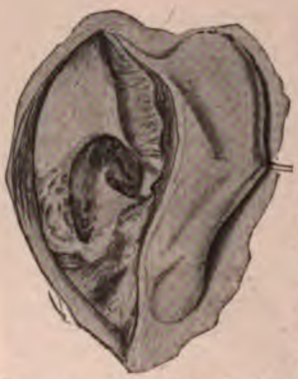


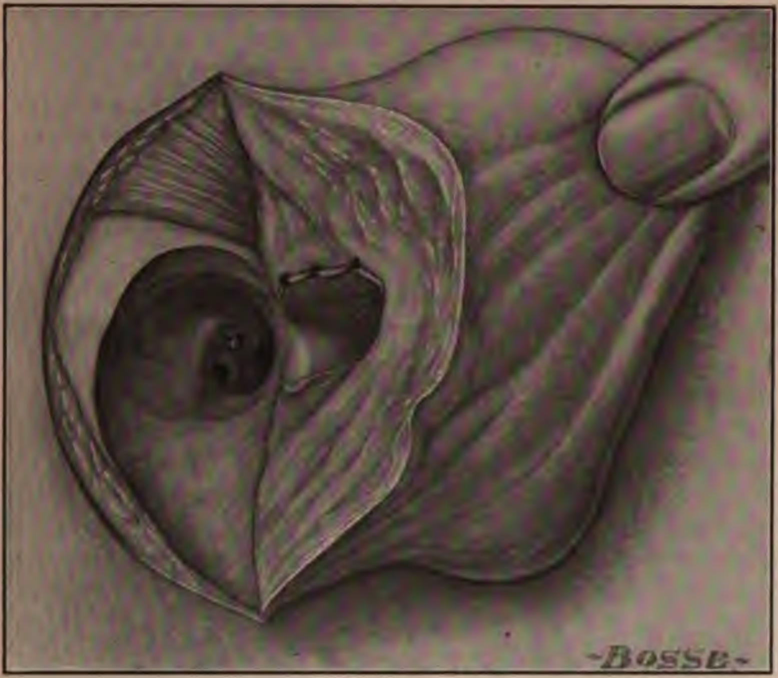
FIG. 147.—Complete Stacke-Schwartze operation. The mastoid cells and middle ear have been thrown into one large cavity, continuous with the external auditory meatus. (From dissections by the author.)

The curette should also be introduced well into the tympanic orifice of the Eustachian tube, so as to cause a closure of this tube, to prevent subsequent infection of the middle ear from the naso-pharynx. The inner extremity of the floor of the canal should also be carefully removed as low down as the tympanic floor, thus obliterating the hypotympanic space. The inner extremity of the posterior wall of the canal should also be cautiously removed, so as to obliterate the posterior tympanic space. Both of these procedures are best effected by means of a curette. The gouge may be used cautiously, but the final steps are best carried out with a curette.

All of the deeper bony dissection is best done with the aid of either the forehead mirror, using reflected light, or of the electric head lamp.

After all carious bone has been removed and the hæmorrhage stopped from all bleeding points, the operator proceeds to line the cavity with epithelial flaps derived from the posterior wall of the fibro-cartilaginous meatus and from the concha. Stacke, in his earlier operation, advocated the splitting of the fibro-cartilaginous meatus along the posterior aspect,

PLATE XII



THE COMPLETED RADICAL OPERATION.

This plate shows the completed radical cavity, showing the prominence of the horizontal semicircular canal. The stapes is in position. The niche of the round window and the tympanic orifice of the Eustachian tube are well shown. The meatus has been enlarged by the formation of a proper flap, and this flap is shown stitched in position. (Author's dissection.)

and tucking the two triangular flaps thus formed, the one upward and backward and the other downward and backward into the bony cavity formed by the enlargement of the fundus of the canal.

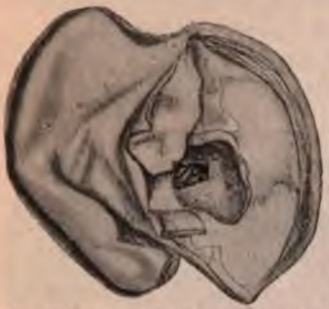


FIG. 148.—Stacke-Schwartze operation. Formation of flaps by Panse's method. (From dissections by the author.)

Panse modified this procedure, converting the horizontal incision along the posterior wall of the canal into a T-shaped incision, by making one cut upward and another downward where the horizontal incision along the posterior wall of the meatus extends into the concha. In this manner, two quadrilateral flaps are formed, one which is turned upward and the other downward, so as to more perfectly line the cavity formed by the extensive removal of the bone. These two flaps are held in position by means of sutures which pass through the flaps and bend the upper flap forward and upward upon itself, while the lower flap is bent backward and downward upon itself. All sutures pass through the quadrilateral flaps and through the soft structures in the anterior flap.

Another modification of the plastic operation is that of Koerner, who, instead of dividing the fibro-cartilaginous meatus by a horizontal incision, makes one horizontal incision along the upper and posterior margin of the fibro-cartilaginous tube and the other along the postero-inferior margin. This incision is extended out into the concha. In this way, a single quadrilateral flap is formed, which can be forced backward into the bony cavity.

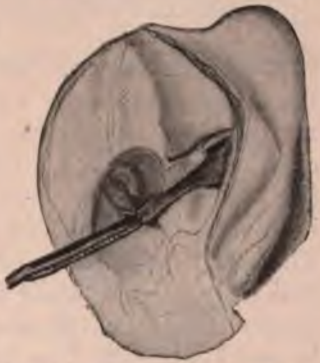


FIG. 149.—Stacke-Schwartze operation. The long tongue-shaped flap, formed according to Koerner's method, is seen drawn outward and backward by means of a clamp. (From dissections by the author.)

The cartilaginous structure of the concha interferes materially with the reflection of this flap backward into the bony cavity, which it is supposed to line. In order to obviate this difficulty, Jansen,* of Berlin, advocates the dissecting out of the cartilage, thus making the flap thin and allowing of its easy displacement into the bony cavity. I have attempted this method in one case, and the result was fairly successful.

Still another method is that recommended by Ballance,† in which a tongue-shaped flap is formed, which includes practically the entire area of the concha. This flap is cut from the auricle by passing a thin knife into the external auditory meatus, just behind the tragus. The knife is then passed downward and made to divide the integument along the entire anterior, inferior, and posterior aspects of the concha, the incision stopped just below the anterior crus of the antihelix. The tongue-shaped flap thus formed is dissected up from the underlying cartilage and the cartilage is excised. This tongue-shaped flap is then turned upward and backward, and is held in position by retention sutures against the corresponding raw surface of the anterior auricular flap—that is, the two raw auricular surfaces are brought together. It will be seen that in this way a cutaneous flap is formed which, on turning the auricle backward, fits for a considerable distance into the upper and posterior portion of the bony cavity, and thus serves to line this with integument.

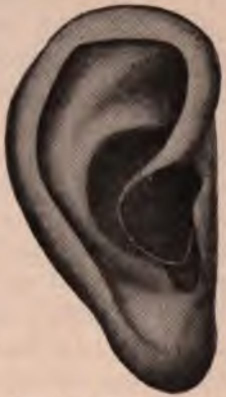


FIG. 150.—Incision of concha to form conchal flap. (Ballance.)

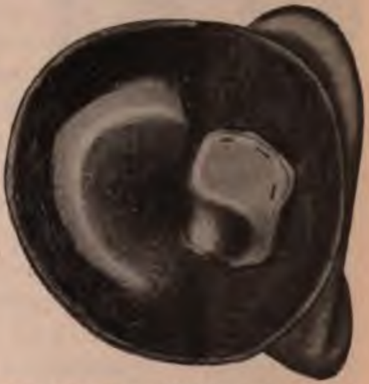


FIG. 151.—Conchal flap sutured in position. (Ballance.)

Ballance also advocates the subsequent lining of the entire bony cavity, at a period of ten days after the primary operation, with skin grafts after the Tiersch method, the posterior wound being reopened for the purpose of inserting the grafts.

---

* Verhandlungen der deutschen otologischen Gesellschaft, Siebente Versammlung in Würzburg, p. 196.

† *Loc. cit.*

From my own experience, I can say I have formed flaps in all of the above-mentioned ways, and believe that the exact flap to be formed must depend upon the particular conformation of the parts in each individual case. I might say, in regard to the Panse method, that for some time I have adopted a modification which has been very valuable to me. Instead of bending the upper and lower flaps backward upon themselves and suturing them to the anterior flap, to which they are already attached, I have passed deep sutures of heavy catgut through the entire depth of these flaps and sutured them to the periosteal margin behind the mastoid wound. The upper suture passes through the outer extremity of the upper quadrilateral flap and through the periosteal margin of the posterior wound adjacent. When traction is made upon this suture the quadrilateral flap is pulled upward, outward, and backward, so that its cutaneous surface forms a lining for the upper part of the bony cavity by its raw surface being forced against the walls of this cavity. The lower quadrilateral flap is attached to the periosteal margin of the wound behind and below in exactly a similar manner. It will be seen that the effect of these two sutures is not only to partially line the bony cavity with the flaps thus formed, but also to enlarge considerably the orifice of the external auditory canal so that practically the entire field of operation can be inspected by reflected light through the meatus. When these deep sutures are tied, it will be found that the superficial tissues, which have been divided, will fall

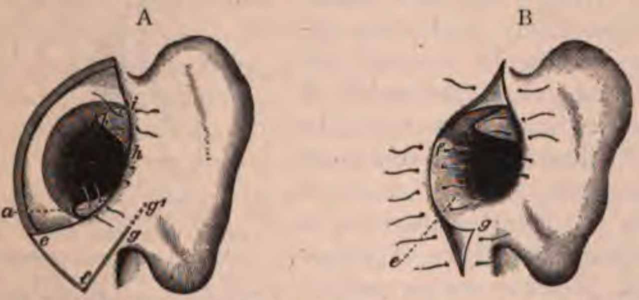


FIG. 152.—Method of lining the operation wound by means of a skin flap taken from the neck, just below the tip of the mastoid. (Passow's method.) A. *e*, *f*, *g*, Flap cut from below. B. Flap rotated into postero-auricular opening and sutured in position. In this plastic operation a permanent retro-auricular opening remains.

backward into fairly good approximation. These sutures being of catgut, have been buried, and have served to hold not only the flaps in place and to force them respectively well upward and downward into the canal, but have also served to bring the cutaneous margins of the external wound in pretty close apposition.

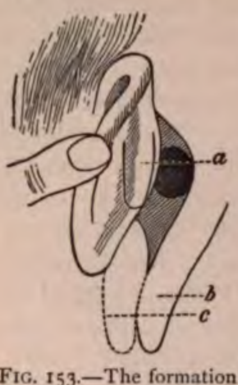


FIG. 153.—The formation of flaps for lining the bony cavity after radical operation. *a*, Flap taken from posterior surface of auricle; *b*, *c*, Flaps taken from tissues of neck below mastoid. A post-auricular opening remains after this operation. (Method of Jansen and Forselles.)

It will be understood that whatever form of flap operation is chosen, and in whatever manner these flaps are secured in place, the posterior wound is ultimately to be closed completely by either silk, silkworm-gut or catgut sutures. My own preference is to put in several sutures of silkworm-gut, passing through the entire thickness of both the anterior and posterior flaps. These sutures pierce the integument of the anterior and posterior flaps anywhere from five sixteenths of an inch to half an inch from their margins respectively, and also, being passed deeply, support the tissues and insure firm union of the deeper structures throughout. At intervals between these silkworm-gut sutures, I have been in the habit of inserting a few superficial sutures of rather fine silk, so as to secure perfect approximation of the entire line of incision. In certain cases, I have used nothing but catgut sutures, the advantage in their use being that they are absorbed, and the inconvenience to the patient, of their removal, is avoided. Provided the suture material is sterile, it is of very little importance what kind of suture material is employed to hold the flaps in position.

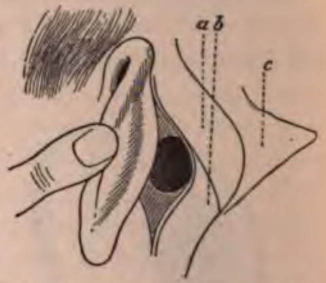


FIG. 154.—Method of lining bony cavity with skin flaps. *a*, Flap taken above from posterior margin of mastoid wound; *b*, Flap taken from posterior margin of mastoid wound below; these two flaps are dissected upward and then turned into the tympanic cavity; *c*, Area along which skin is undermined after these flaps have been formed so as to enable approximation of the edges of the wound over the flaps. (Method of Schwartze and Kretschmann.)

In all of the methods of operation previously detailed, the idea of the operator should be to drain the middle ear entirely through the meatus, closing the wound behind the ear completely. Certain operators, as Passow, Jansen, Reinhardt, Kretschmann, and Schwartze, have advocated lining the cavity already formed in the mastoid, with cutaneous flaps obtained from the integument of either the anterior or posterior flaps, thus leaving a permanent opening behind the ear. While it is possible by any of these methods to form a tegumentary lining for the cavity, composed of mastoid cells, middle ear, and external auditory meatus, the unsightly deformity which results from a large permanent opening behind the ear seems to me to constitute a radical objection to all of these methods.

The methods of formation of these flaps will be easily understood from the appended figures, which are reproduced from the excellent work of Jacobson.*

In a number of my cases, for the last year, I have dissected out more or less of the cartilage of the concha, and in every instance have found the results of the plastic operation were much better when this was done than when the flaps were allowed to remain of their original thickness. I have also made use of the tongue-shaped flap, with the dissecting out of the cartilage after the Ballance method, but have slightly modified the manner of holding the flap in position.

After the tongue-shaped flap has been cut from the concha and the cartilage dissected out, the cutaneous flap is pulled upward and backward into the posterior wound and its raw surface applied to a corresponding raw surface on the anterior flap consisting of the auricle. In other words, the flap is bent backward upon itself and the tissues are sutured together, raw surface to raw surface, by means of catgut sutures. In this way, the meatus is not only enlarged, but by the stitching up of the tongue-shaped flap, in the manner above described, a cutaneous lining is formed for the upper portion of the bony cavity, when the auricle is replaced and the posterior wound sutured.

I have never attempted to line the middle-ear cavity by means of the Tiersch grafts, by reopening the posterior wound, as advocated by Ballance, but in one instance secured an admirable result by lining the entire wound through the external auditory meatus, the opening which was left after the plastic operation being so ample that the grafts could be inserted without great difficulty. Instead of opening the posterior wound at a later period for the introduction of Tiersch grafts, I have lately had very good success in introducing these grafts at the time of the primary operation. After all carious bone has been removed and the flaps formed from the meatus and concha by any of the methods above detailed, as the necessities of the case have seemed to indicate, I have then proceeded to line the entire cavity of the middle ear as completely as possible by means of Tiersch grafts taken from the thigh of the patient. As large a graft as possible should be cut and carefully slid off from the razor on to a broad spatula. These grafts are more easily transferred if they are slightly moistened with a few drops of a normal salt solution. Care should be taken to spread the graft out flat upon the spatula and to see that its edges do not curl under. The graft is then quickly but carefully slid from the spatula into the bony cavity which it is intended to line. To transfer the graft in this way a long, straight needle seems to be the best instrument. The spatula having the graft

---

* Lehrbuch der Ohrenheilkunde für Aerzte und Studirende, L. Jacobson and L. Blau, Leipzig, 1902.

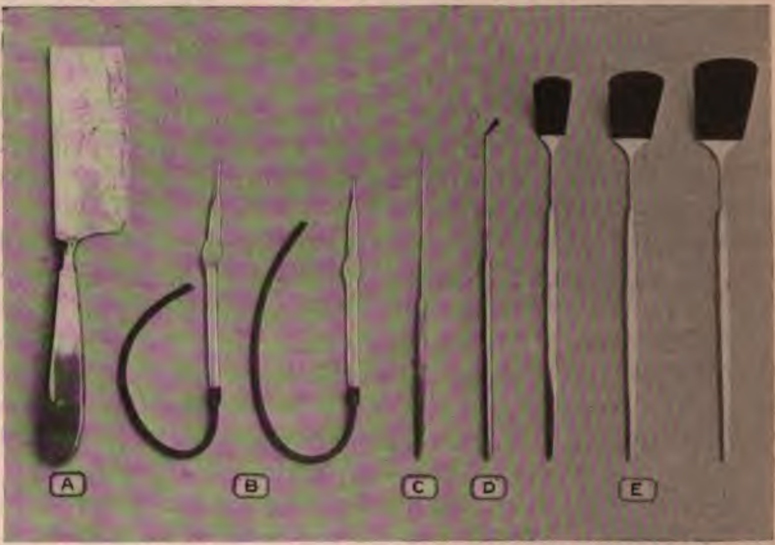


FIG. 155.—Ballance's instruments for skin grafting. A, Large razor for cutting grafts; B, Pipettes for removal of air and blood from beneath the grafts when in position; C, Needle for manipulating graft; D, Blunt instrument for pressing grafts on bony wall and for packing pledgets into tympanic cavity to hold grafts in position; E, Broad spatulæ upon which graft is spread and from which it is carried into the tympanic cavity.

in position is carried as close to the operation wound as possible. The edge of the graft nearest the wound is then carried rapidly from the spatula across the wound surface from behind forward. While this manipulation, from its description, may seem to be difficult, it is in reality very simple to slide the graft from the spatula into the wound, and to so place it that it will completely fill the fundus of the canal, covering the roof of the tympanum, and the deeper portion of the spur of bone which forms the wall of the facial nerve and horizontal semicircular canal. It is important that the bony cavity should be as dry as possible before the graft is put in position; to this end, the cavity may be packed with either sterile gauze or with gauze saturated in a solution of adrenalin chloride 1 to 1,000 until the operator is ready to introduce the graft. The packing is then removed by an assistant and the graft quickly slid into position. In spite of all care there will be a little oozing under the graft. This blood is best removed by means of a thin, fine glass pipette introduced under the margin of the graft, suction being applied to the pipette by the lips of the surgeon or of an assistant. In this way all air bubbles are removed and the graft falls naturally into position upon the surface. This ingenious method of applying the grafts was, I think, first suggested by Mr. Ballance. After the graft is in place, it should be maintained in position by a firm packing of pledgets of sterile cotton. These pledgets are frequently impregnated either with aristol, xeroform, iodol, or some such antiseptic powder, the idea being to keep the bony cavity as dry as possible in order to favor the vivification of the grafts. These cotton pledgets are packed upon the surface of the graft, and are pressed firmly inward upon the bony wall by means of a smooth steel instrument which allows the cotton pledget to be manipulated considerably, while, at the same time, the smooth surface of the instrument does not catch the graft and tend to pull it away from the bony surface to which it is applied. The entire cavity is filled with these cotton pledgets, the average number of pledgets introduced being somewhere between seven and ten. After the graft has thus been carefully applied, the posterior wound is sutured in the manner already detailed. The dressing is usually changed at the end of forty-eight hours and the stitches removed. Unless there is some rise of temperature or a profuse purulent discharge from the canal, the pledgets holding the grafts in position are not removed until the fifth or sixth day after operation. When these pledgets are removed the grafts will usually be found adherent over the greater part of the operation cavity.

Where any odor is present at the first dressing it is well to remove at once the pledgets holding the grafts in position. Such an odor, however, does not necessarily mean that the graft may not have taken over a portion of the surface to which it was applied, as the odor may be due to a necrosis of that portion of the graft which has not adhered to the underlying bone. In some cases it may be difficult to remove all the pledgets at this time, in which event the meatus should be syringed with equal parts of peroxide of hydrogen and sterile water, in order to thoroughly cleanse the cavity. This peroxide irrigation is to be followed by an irrigation of normal saline solution. The use of peroxide of hydrogen not only tends to cleanse the cavity, but also to loosen the pledgets which have been employed to hold the grafts in position and to render their removal easier. After irrigation in this manner the cavity is dried, a light gauze packing inserted, and the wound dressed in the usual way. Daily dressing of the wound is then advisable. The pledgets remaining may be removed at subsequent dressings until all have been accounted for. It is never wise to use any undue violence in searching for these pledgets or in attempting to extract them as, in this way, a graft may be detached which would otherwise have adhered to the underlying bony wall. At the end of from seven to ten days after the operation, all posterior dressings can usually be removed, and the line of incision covered with a collodion dressing. The external auditory canal need not be packed, but it will be wise to insert a pledget of sterile cotton lightly into the meatus, to prevent infection from without. This cotton should be changed either by the patient or nurse as often as it becomes saturated with discharge. The canal is to be cleansed several times daily by irrigation, either with a solution of bichloride of mercury, of a strength of 1 to 10,000, or a normal saline solution, until the ear becomes perfectly dry.

Regarding the results following these operations:

Out of two hundred and seventy cases operated upon, one hundred and sixty-six were cured and seven died. In thirty-three there was a slight discharge remaining, in eight there was a moderate discharge, and in eight a profuse discharge. In thirty-six cases the result of the operation was unknown; twelve cases were still under treatment at the time of collation of these statistics.

I do not believe that subsequent experience will demonstrate the necessity of doing a secondary operation, in the majority of cases, in order to secure dermatization of the tympanic cavity by means of the Thiersch graft. Of course, secondary operations for this purpose will be necessary in some cases, particularly in those where the purulent discharge has been very profuse, and where it is practically impossible to obtain a fairly aseptic wound at the time of the first operation. Certain cases of this kind have come under my observation. Here, I simply pass the deep sutures already mentioned, but do not suture the cutaneous wound. As soon as the middle-ear cavity seems to be in a fairly aseptic condition, the grafts are then applied and the superficial wound sutured. The passage of the deep sutures insures the maintenance of an ample meatus and rather favors the subsequent coaptation of the cutaneous parts, while it in no way interferes with the application of the grafts.

Accidents during Operation.—Regarding the dangers of this operation, a few remarks may not be out of place. The danger which we usually seek to avoid is injury of the facial nerve. This can be avoided in almost every instance by carefully following the upper wall of the canal, removing the external wall of the epitympanic space—that is, the roof of the meatus close to the middle ear—and in this way exposing the *aditus ad antrum* and anterior portion of the antrum. The prominence of the semicircular canal and the aquæductus Fallopii will then come into view. If these parts are exposed and recognized, the curette may then be used quite freely but cautiously, both upward and downward, in order to enlarge the opening between the antrum and the middle ear without injuring the facial nerve. Of course, throughout the entire procedure the face should be carefully watched for any evidences of mechanical irritation of the facial nerve by instruments. In addition to the danger of facial paralysis, the operation can not be absolutely free from danger to life. The middle cranial fossa occasionally lies so low that even with the most careful use of the chisel, the removal of the roof of the meatus will expose the dura. This has happened to me in four cases. In two of these instances the dura itself was wounded by a spicule of bone, and on carefully introducing the probe for purposes of exploration the probe went directly into the cerebral substance. Both of these cases made a complete recovery.

Another accident which has happened in my own case, and to at least two of my colleagues, has been the accidental exposure of the lateral sinus, where this vessel lay very far forward. It would even be possible to wound the lateral sinus, during the operation, where this vessel was greatly misplaced, in spite of the greatest care on the part of the operator. While accidents of this kind must be exceedingly rare, their occasional occurrence can not be entirely avoided, even by exercising the greatest care in technique. The surgeon should always remember, therefore, in performing this operation, that he is liable to expose the dura, or even to open it, even in the middle cranial fossa or over the lateral sinus, at some stage of the operation. It is therefore of the utmost importance that the operation be conducted with the greatest attention to aseptic technique. In those cases where these accidents have happened in my own practice, I have attributed the recovery of my patients solely and entirely to the fact that the technique of the operation was as perfect as I could make it. The mere exposure of the dura in the middle fossa, or the exposure of the lateral sinus should not ordinarily be followed by any symptoms. As soon as the surgeon discovers that the cavity of the cranium has been invaded, he should pack off this area, using a strip of iodoform gauze for the purpose, so as to completely isolate the part exposed from the operative field; he may then proceed to rapidly remove all deeper foci of purulent infection by the free use of the curette and gouge, so as to prevent subsequent infection of the deeper parts from the original focus of suppuration. Where the field of operation is so contracted as to render it impossible to pack off the dural area separately, care must be taken in clearing out the deeper portion of the wound to sweep all of the detritus downward and outward, rather than upward and outward, in which latter instance it would pass directly over the exposed dura and be liable to infect it. In those cases where the brain substance is not wounded or the sinus opened, the mere exposure of the dura need not deter the surgeon from proceeding in the ordinary manner—that is, the cutaneous flaps may be formed in the usual way, sutured in position, and the entire posterior wound closed by sutures. In packing the canal, it has been my custom, excepting in those cases where the canal was so narrow as to render it impossible to pack off the exposed sinus or exposed dura in the middle fossa separately from the other wound, by introducing a separate packing over the dural area, so as to avoid any infection of the meninges or of the sinus from the discharge from the canal. It is also wise in these cases to change the dressing every second day, thus keeping the parts clean. Where the brain substance is entered, if the area has been kept thoroughly cleansed prior to the time of operation, and if the operator is convinced after curettement that no focus of infection has been left, he may then close the wound completely, as above described. If there is any doubt about the cleanliness of the wound, however, the surgeon will do well to pack off the site of the dural wound separately, and to defer suturing the posterior wound until at least ten days after the primary operation, packing the parts firmly with iodoform gauze, so as to guard against secondary infection.

Among one of the rarer accidents which may follow the radical procedure is an extensive perichondritis of the auricle. This occurred in one of my cases, from no assignable cause. In this instance the perichondritis was very extensive, and in spite of prompt operative interference considerable deformity of the external ear resulted. A similar case is reported by Politzer.*

---

* Lehrbuch der Ohrenheilkunde, 4th ed., Stuttgart, p. 462.

SECTION IV.

THE SURGICAL TREATMENT OF INTRACRANIAL COMPLICATIONS OF AURAL SUPPURATION.

FIG. 156.—Lateral aspect of skull, showing Reed's base line. This is a horizontal line drawn from the lower margin of the orbit to the occipital protuberance. This line will pass through the centre of the external auditory meatus. In the figure, the line is divided into quarter inches. *C*, A point one inch above the centre of the meatus, the site of election for entering the cranial cavity for exploratory purposes. *D*, A point an inch and a quarter behind, and an inch and a quarter above a horizontal plane, passing through the centre of the external auditory meatus; this is the point usually given as the site of election for opening a temporo-sphenoidal abscess. If the opening into the cranial cavity is made at the point *C*, as advised in the text, it will be seen that it is only necessary to enlarge the opening in the bone backward in order to reach the portion of the temporo-sphenoidal lobe indicated by *D*. *E* is a point on Reed's base line, seven eighths of an inch behind the external auditory meatus. This point corresponds to the knee of the lateral sinus; the knee of the sinus may be found in front of this point or sometimes behind it. The site of election for opening a cerebellar abscess is a point one and one half inches behind the centre of the meatus, measured along Reed's base line, and a quarter of an inch below this line. *F* in the figure represents a point two and a half inches behind the centre of the meatus on Reed's base line. The opening may be extended posteriorly toward the median line, as far as the point *F*, in exploring for a cerebellar abscess. *A*, Fissure of Rolando. This fissure is found by drawing a line from the root of the nose over the top of the head to the occipital protuberance. A point .557 of the distance backward on this line is then taken; this point corresponds to the upper end of the Rolandic fissure. As the fissure extends downward and forward at an angle of 67° with this line, it is only necessary to take a piece of paper so folded as to make an angle of 67°, and applying one side of the triangle to the line already drawn, the other side of the triangle will correspond to the fissure of Rolando. This fissure is about three and a half inches in length. *B*, Fissure of Sylvius. To find this fissure, draw a line parallel to Reed's base line from the external angular process of the frontal bone. Take a point one and one quarter inches behind the external angular process on this line and a quarter of an inch above it. This marks the anterior extremity of the fissure. Next find the parietal eminence and from this point draw a line downward, perpendicularly to Reed's base line. On this line mark a point three quarters of an inch below the parietal eminence; this gives the second point. A line drawn from the anterior extremity of the fissure, through this second point and extending backward for four inches, will mark the fissure of Sylvius. (Author's specimen.)

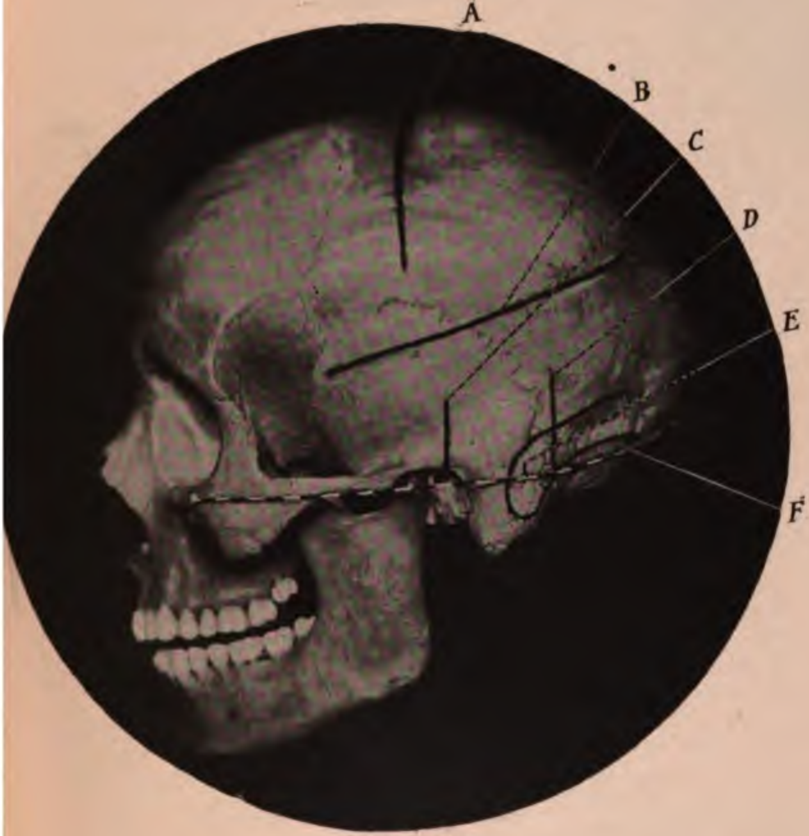
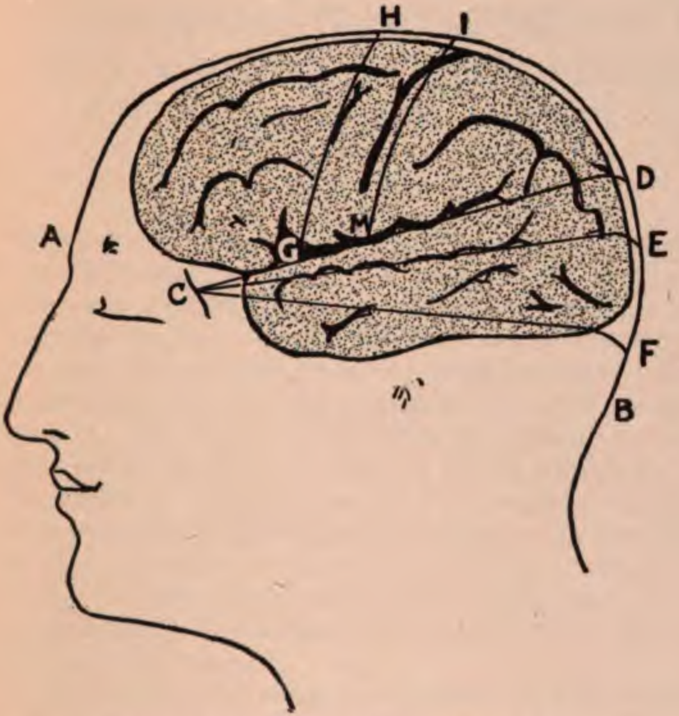


FIG. 156.

PLATE XIII



CRANIO-CEREBRAL TOPOGRAPHY. (CHIPAULT.)

In this plate *A* is the naso-frontal suture and *B* the occipital protuberance. *C* is the retro-orbital tubercle. On the line *AB*, *H* is a point .45 the length of this line, *I* .55, *D* .70, *E* .80, and *F* .95 the length of this line. From *C* three lines are drawn to *D*, *E*, and *F*, respectively. *G* is a point .2 the length of the line *CD*, and *M* is a point .3 the length of the line *CD*. If the points *H* and *G* are joined, we have the pre-Rolandic line, and if *M* and *I* are joined, we have the Rolandic line; that is, the line of the fissure of Rolando. The line *CD* represents the Sylvian fissure, the line *CE* the parallel fissure, and the line *CF* corresponds very closely to the horizontal portion of the lateral sinus. The advantages of this method lie in the fact that as all dimensions are proportionate, it is applicable to patients of all ages.

THE SURGICAL TREATMENT OF THE INTRACRANIAL COMPLICATIONS OF AURAL SUPPURATION.

When it has been decided that the intracranial structures are involved either subsequent to an operation on the mastoid or when the case first comes under observation, it is wise to institute surgical measures for the relief of the condition. It has been argued that, from the great mortality following such measures, they are not justifiable; but when we remember that the only chance of relief lies in surgical interference, it seems wrong to refuse the patient this opportunity.

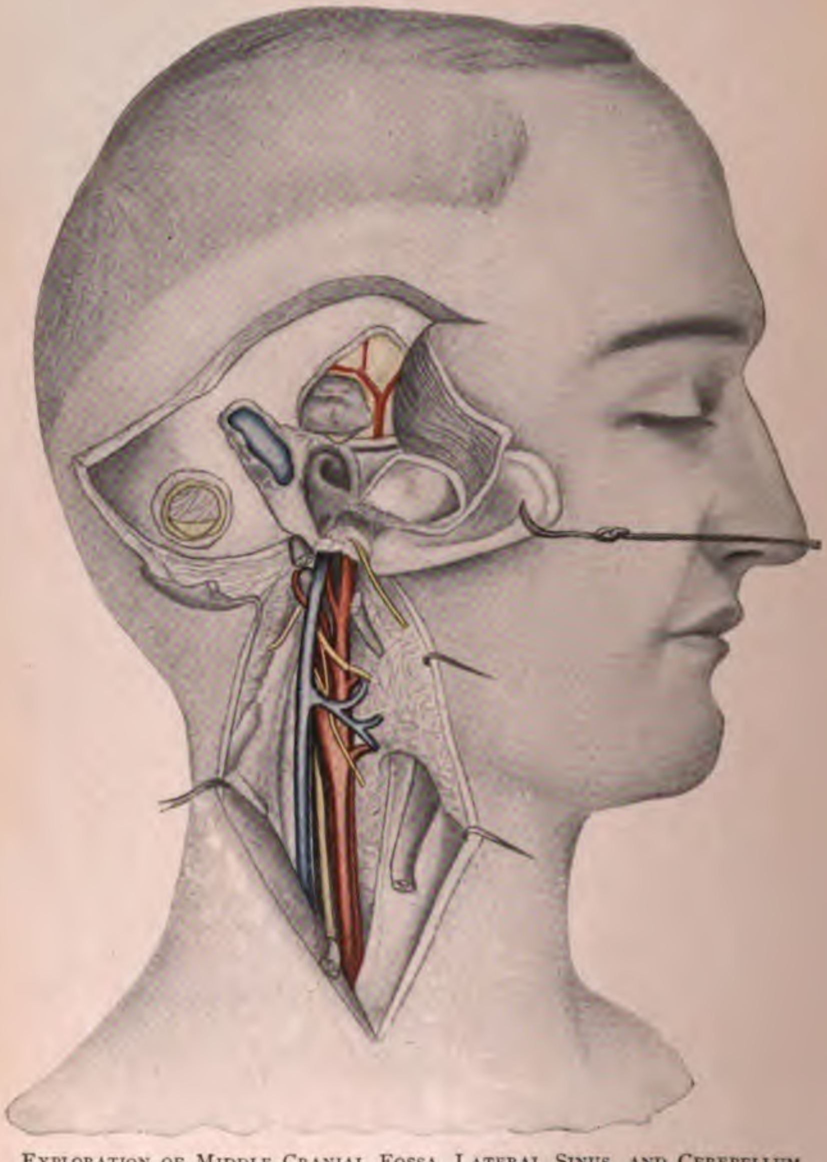
In purulent meningitis surgical interference offers less promise than in epidural or cerebral abscess, or in sinus thrombosis, when prompt action on the part of the surgeon often saves life. It is only when unmistakable symptoms of extensive meningitis occur that we should hesitate in performing an operation in any of these cases.

It is well, in undertaking an operation for the relief of an intracranial lesion following a middle-ear inflammation, to remember the advantage of having the opening in the soft parts sufficiently ample to permit of extending the opening in the skull in various directions, if desirable, without enlarging the cutaneous incision.

The operator may wish to explore the middle fossa, the sinus, and the cerebellum at the same operation, and to expose each of these areas, as a separate procedure would entail the expenditure of much valuable time. It is wise, therefore, to expose the bony surface over an area which includes the various sites of election for entering the cavity (Fig. 156). The author has found that the exposure is best effected by the displacement of a semicircular flap, as shown in Plate XIV. This flap is formed by extending the incision, made at the time of the mastoid operation, forward above the zygoma for a distance of an inch and a half. From the middle of the original mastoid incision an incision is made backward to the occipital protuberance. This incision is slightly curved, the convexity being directed upward. If the soft parts are now dissected up, a large flap can be turned down upon the neck, exposing the surface of the cranium. The flap is supplied by the vessels which enter from below, and the danger of sloughing is avoided. All attached muscles are divided longitudinally, and hence their action is in no way destroyed.

In dissecting up this flap, the periosteum is not detached; this is undisturbed, except where the bony wall is removed to effect an entrance to the cranial cavity.

PLATE XIV.



Exploration of Middle Cranial Fossa, Lateral Sinus, and Cerebellum. Ligation of Internal Jugular. (Author's dissection.)

CHAPTER XXX.

SINUS THROMBOSIS.

WHERE the mastoid has been previously opened, the simplest means of exposing the lateral sinus is to remove the bone directly behind the mastoid antrum and perforate the skull at a point about seven eighths of an inch behind the centre of the bony meatus, and a quarter of an inch above a horizontal plane passed through this point. In other words, the sinus will be exposed by perforating the skull at a point approximately half an inch behind the posterior margin of the external auditory meatus. The position of the sinus varies considerably in different individuals, but it is seldom placed farther backward than this, although occasionally it may lie three quarters of an inch behind the posterior margin of the osseous meatus.

Whenever the sinus is to be explored, too much attention can not be paid to the technique of the operation. The surgeon should always remember that he is possibly exposing a healthy blood vessel of considerable size, and that, therefore, the dangers of infection are many, unless perfect asepsis is observed. If the mastoid operation has been done at the same time, it is well to have all instruments resterilized, and the field of operation surrounded either by dry sterilized towels or by fresh towels moistened in a solution of bichloride of mercury of a strength 1–1,000; the hands of the operator and those of his assistant should also be recleansed before proceeding with this exploratory operation.

In exposing the sinus the bone may be removed rapidly, as there is very little danger of perforating the sinus wall by means of the chisel or gouge, if ordinary care is used. As soon as the chisel has perforated the inner table and the dura is exposed, the opening should be rapidly enlarged upward and downward by means of the rongeur forceps. Care must, of course, be taken not to endanger the wall of the sinus by the use of this instrument. This warning is particularly necessary in dealing with those cases where the sinus wall is necrotic, as here even a slight amount of violence may break down the wall of the blood vessel. It is sometimes wise, previous to introducing the rongeur forceps, to pass a director cautiously between the dura and the skull, so as to separate the dura from the bone and allow the passage of the lower blade of the rongeur into the cranial cavity, thus enabling the surgeon to enlarge the opening with perfect safety.

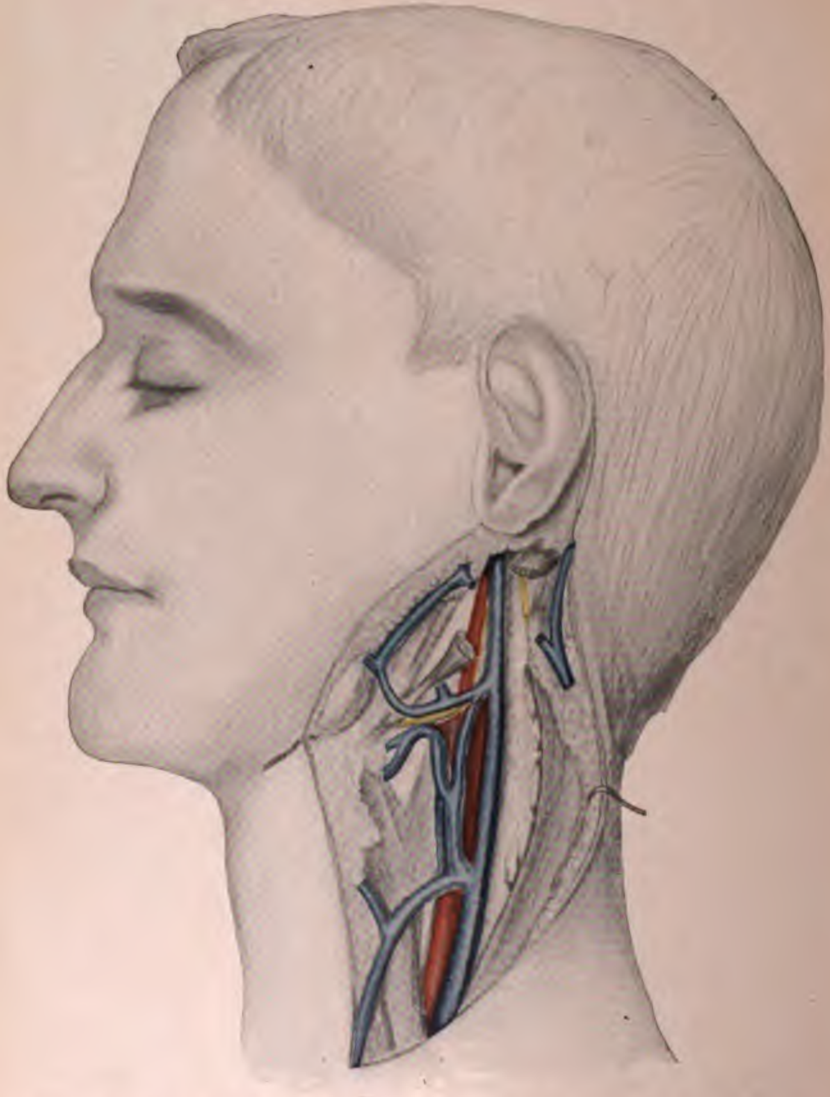
In exposing the sinus for purposes of exploration, it should be remembered that it is necessary to remove the bony covering for a considerable distance. It is never wise to assume that the sinus has been properly explored unless it has been uncovered for a distance of at least three quarters of an inch, and it is better to expose it over a longer rather than over a shorter length. The area of exploration should begin at that part of the sinus lying just behind the mastoid antrum. The bone over the sigmoid groove should then be removed, so as to expose the knee of the sinus, and as far down toward the bulb as possible. It is no easy matter to determine either by inspection or palpation whether or not the vessel is perfectly healthy. Some information may be gained by taking into consideration the color of the dura, the presence or absence of pulsation in the sinus, both upon inspection and palpation, and the aspiration of the sinus on deep inspiration. On palpation, if the sinus is normal, the wall of the vessel feels smooth and yielding to the touch, distinct pulsation is usually felt; by moderate pressure the finger is able to map out somewhat roughly the lateral extent of the venous channel. In other words, the normal sinus feels exactly as any large vein would feel under the finger, its fluid contents being easily expelled, and the channel filling rapidly with fluid blood as soon as the pressure is removed. Pressure at the lower part of the sinus will cause a slight dilatation of that portion of the channel above the palpating finger. In spite of all these signs, however, it is entirely possible that a small clot in the sinus may be occasionally overlooked. If the surgeon is in the least doubt, therefore, as to whether or not the sinus is normal, the only course is to make an exploratory incision.

In a former edition I advocated puncture of the sinus wall for exploratory purposes by means of the aspirating needle. Experience has taught me that exploratory puncture of the sinus is absolutely without value, as a parietal clot may be punctured, fluid blood may be withdrawn by the aspirating needle, and the operation prove entirely useless, therefore, for exploratory purposes. The only way of determining the presence of a clot in the sinus is to make a free incision in the sinus wall. This should be done preferably at the lower portion of the exploratory opening—that is, just below the knee of the sinus. The vessel should be compressed by the finger above, and a sharp bistoury made to divide the wall of the vein longitudinally for a distance of about a quarter of an inch. If free hæmorrhage occurs from below, the finger should be placed just below this opening. If the channel is normal, free hæmorrhage will then occur from above. The exploratory operation may then be considered as having revealed a perfectly normal sinus. A strip of iodoform gauze, one extremity of which has been folded over upon itself several times, is then placed over the opening in the sinus, and the remainder of the strip of gauze is packed down and held in position by the finger of an assistant. In this manner the hæmorrhage is controlled. If, upon making an incision in the lower portion of the sinus, free hæmorrhage does not occur, the pressure above should be taken off, to see if hæmorrhage occurs from above. The absence of hæmorrhage in either direction indicates the presence of a clot. In cases where there is no hæmorrhage upon removing all pressure after incision of the sinus wall, the incision in the wall should be extended upward for at least a quarter of an inch more, thus making the incision in the wall one half an inch long. A blunt curette should then be introduced into the lumen of the sinus, first downward toward the bulb, and the clot carefully but thoroughly removed. The curette should be passed well downward into the bulb, and hæmorrhage from below secured, if possible. After hæmorrhage from below has been established, it should be controlled by a pledget of gauze packed over the lower portion of the opening in the sinus, in the manner already described, and the curette should then be used in the opposite direction, and the clot broken down until free hæmorrhage results. The bleeding should be controlled by packing between the sinus and the skull so as to obliterate the sinus.

It is well to remember here, that while it is imperative to establish, if possible, free hæmorrhage from below, free hæmorrhage from above is not so important. If free hæmorrhage from below does not occur, it indicates that the clot has extended downward through the bulb and into the internal jugular vein, from which point it is continually infecting the general circulation by the venous tributaries which enter the internal jugular below the base of the skull. If, however, the sinus is completely plugged at the bulb, systemic infection can scarcely take place from any point above the jugular bulb, consequently it is well not to curette out the upper portion of the wound too thoroughly or too persistently. If there is a soft clot in this region and it can be broken down easily by means of the curette, free hæmorrhage being established, then the clot should be broken down. If, however, the clot seems very firm and extensive, it is quite possible that it may extend well out toward the torcular, and that its upper portion may be non-infectious. It would, therefore, be unwise to disturb such a clot, as further decomposition would probably be avoided by properly curetting and packing the sinus wound with iodoform gauze. While we know from autopsies that infection through the opposite veins, through the torcular Herophili, does occur, such cases are so uncommon as to warrant their being practically disregarded—certainly at the time of primary operation, and the aim of the surgeon should be to prevent infection from the sinus through the jugular of the same side.

In cases where there is evidence of profound systemic infection, the surgeon should remember that the mere fact that free hæmorrhage occurs from below after opening the sinus does not indicate necessarily that the jugular has not been involved. As the channel through which infection of remote parts of the body occurs is a continuation of the lateral sinus—that is, the internal jugular vein—it often becomes necessary to cut off this large afferent channel in order to prevent the further absorption of septic material. If the case has been under observation for some time, it is possible that the surgeon may make a diagnosis of extension of the thrombus into the internal jugular. Such a diagnosis would depend upon great temperature fluctuations—that is, a temperature rising suddenly to 105° or 106°, and then falling spontaneously in a few hours to normal or subnormal. In addition to this symptom, there would be other evidences of poisoning, such as asthenia, emaciation, and profuse perspiration. Locally, it is sometimes possible, in cases where the clot has extended into the internal jugular vein, to make out, upon palpating the neck, a tense, cord-like band fol-

PLATE XV.



DISSECTION OF INTERNAL JUGULAR VEIN, SHOWING FREE VENOUS ANASTOMOSIS ON THIS SIDE AS CONTRASTED WITH PLATE XIV.

(Opposite side of same subject, author's dissection.)

lowing the course of the internal jugular. Many authors seem to lay considerable stress upon this point; personally, I have never observed this physical sign. We must remember that the upper portion of the internal jugular vein lies deeply, the vessel being covered by the digastric muscle, deep cervical fascia, the parotid gland, the platysma, and the integument. Bearing in mind the fact that the deep lymphatic channels of the neck, like the deep cervical fascia, follow the general course of the vessels, and remembering how quickly these glands become involved whenever any septic process occurs in the adjacent region, it is at once evident that a thrombus in the internal jugular may hardly be recognized by palpating the neck until this thrombus had extended well down the lumen of the vein; certainly, below the level of the larynx. In a number of my own cases there has been a hard, brawny swelling in the region of the parotid gland and along the anterior border of the sterno-mastoid muscle. In some cases I have been able to detect a tender point just at the anterior border of the muscle and just behind and above the angle of the jaw. The cord-like feeling, however, which is said to be indicative of the presence of the thrombus in the internal jugular vein, I have never observed. General tumefaction, then, and a tenderness along the anterior border of the sterno-mastoid muscle, together with great fluctuations in temperature, would lead the surgeon to suspect in any given case of purulent otitis, with or without mastoid involvement, that the infecting process had possibly extended from the sinus into the vein. I believe, however, that an absolutely certain diagnosis can only be made at the time of operation. If, when the lateral sinus is explored in the manner detailed in the preceding pages, free hæmorrhage does not occur from below, or even if there is considerable hæmorrhage from the lower end of the vein, if the surgeon finds the tissues just behind the angle of the jaw brawny and evidently infected, and if the fluctuations in the temperature have been well marked, he should not be content with clearing out the thrombus from the lateral sinus alone, but should immediately proceed to cut off the return circulation through the internal jugular vein. Ballance was the first to recognize the importance of this procedure. But in the earlier operations a ligature was simply applied to the vein below the point at which the thrombus was found. In some instances, the vein was opened and the blood channel washed out with an antiseptic solution injected upward until the solution flowed out through the opening in the lateral sinus above. For a number of years surgeons have pursued the plan of completely excising the infected vein. The operation is best performed as follows: After the sinus has been explored and curetted, in the manner already described, the shoulders of the patient are elevated upon a pillow, thus rendering the sterno-mastoid muscle tense. The neck is then cleansed from the clavicle to the mastoid, the tissues being manipulated very carefully in order to prevent the breaking down of any clot which may be present in the jugular and the detachment of an embolus from any thrombus which may lie in the vein. An incision is then made from the sternal attachment of the sterno-mastoid muscle upward to the tip of the mastoid, the incision following the anterior border of the sterno-cleido-mastoid muscle. The integument is first divided, and the surgeon then observes the oblique fibres of the platysma. The platysma varies in thickness considerably in different individuals. At the lower part of the neck the muscle is very thin, while above it may be quite thick. As soon as the integument and the platysma are divided, the anterior border of the sterno-mastoid muscle comes into view. By means of retractors, the margins of the wound are separated, the sterno-mastoid being pulled backward. The deep fascia of the neck is then seen, and upon opening this the sheath of the vessels is found to lie immediately beneath the anterior border of the muscle. The common sheath of the vessels, it will be remembered, contains the common carotid artery, the internal jugular vein, and the pneumogastric nerve. The vein always lies to the outer side of the artery, low down in the neck, lying somewhat in front and to the outer side, while higher up in the neck it crosses the carotid just about at the point of bifurcation of this vessel into the external and internal carotid arteries. It then follows the course of the internal carotid artery, and at the base of the skull lies on the outer side and slightly behind this vessel. The pneumogastric nerve lies between the vein and the internal carotid above and between the vein and the common carotid below. It also lies a little behind these vessels. After the sheath of the vessels has been opened, the vein is easily recognized by its dark-bluish color. Firm pressure at the root of the neck will cause the vein to fill with blood, and it can thus be more easily recognized. The first step of the operation is to clear the vein as thoroughly as possible from the sheath. This is best done by some blunt instrument, such as the handle of the scalpel or the closed blades of a pair of blunt-pointed scissors, the connective tissue overlying the vein being raised cautiously by a pair of forceps and torn along the axis of the vessel by means of the blunt scissors or by means of a director; care is necessary in order to thoroughly separate the vessel from the pneumogastric nerve. Although the nerve lies behind the vessel, it is sometimes adherent to the sheath of the internal jugular. Unless care is taken to recognize the nerve at the time of the dissection, it may be included in a ligature passed around the vein. The vein is best cleared by dissecting along its posterior and postero-internal aspect. All of the tributary vessels come off from the anterior aspect of the vein and practically no tributaries are met if the dissection is carried along the posterior wall. The vein should be exposed sufficiently low down in the neck so that two ligatures may be passed about it, below the point to which the clot extends. In some cases, I have followed the vein almost to the innominate. After the vein has been thoroughly exposed, two ligatures are passed about the vessel as low down in the neck as necessary. These ligatures are tied, and the vein is divided between them. The entire vein is then carefully dissected out, all tributary branches being divided between two ligatures as the dissection is continued from below upward. The number of tributaries requiring ligation will vary in individual cases. The branch which always requires ligation is the common trunk of the temporal and facial veins which joins the internal jugular at a point just about the level of the hyoid bone. Occasionally the thyroid and laryngeal branches must be divided between two ligatures as we proceed from below upward before this large trunk is reached. In many instances, however, the thyroid, laryngeal, and lingual branches are so small as to entirely escape observation. When the common trunk of the lingual, temporal, and facial is reached, care must be taken to separate this trunk cautiously from the underlying tissues and to divide it between two ligatures. In two of my cases I have found a clot in the internal jugular extending down as far as the point where the facial vein joins the internal jugular and systemic infection was undoubtedly occasioned by the carrying into the general circulation of portions of this clot by the blood current entering the jugular through the facial and temporal veins. This large branch must therefore be carefully secured and divided between two ligatures. The internal jugular is then followed upward as high as possible, is surrounded by two ligatures and divided between them. As the common trunk of the temporal and facial vein is the last large branch given off from the vein, it is not necessary to follow the vessel completely to the base of the skull. It may be divided with perfect safety at a point three quarters of an inch above where the facial vein enters the internal jugular. I do not think it advisable to attempt to wash out any clot which may be present by the injection of fluid into the upper extremity of the vein. The small segment of vessel lying between the point of ligation and the opening in the lateral sinus can scarcely afford any opportunity for systemic infection. I believe there is much more danger of forcing septic material into the general circulation through the inferior petrosal sinus if fluid is injected into the upper portion of the vein, than if the operation is terminated simply by a ligation of the vessel. After the operation has been concluded the wound in the neck should be flushed with a warm saline solution, and the margins of the wound united by means of interrupted sutures, preferably of silk. The upper angle of the wound should be left open and a packing of iodoform gauze inserted. The opening made in the sinus at the early part of the operation should then receive attention. A strip of iodoform gauze should be inserted at the upper angle of the wound between the sinus and its bony covering, thus occluding the sinus at this point. The lower extremity of the sinus wound may be packed with iodoform gauze inserted directly into the sinus. If the upper extremity of the sinus wound is not treated in this manner, persistent hæmorrhage is apt to follow upon the removal of the packing. The procedure described obliterates the upper portion of the sinus by obliteration of its lumen. The entire mastoid wound should then be dressed in the usual way, care being taken to separate the mastoid antrum from the open sinus by means of gauze packing. Out of fifty-seven cases operated on forty were cured and seventeen died. The causes of death were as follows: one of hæmorrhage into the spinal canal, one of pyæmia (late operation), three of pneumonia beginning before operation, one of diabetes, one of gangrene of the lung, one of gangrene of the neck, and one of malnutrition. In eight cases the cause of death was not recorded.

CHAPTER XXXI.

OTITIC MENINGITIS.

IN instituting operative procedures for a meningitis, the rational symptoms seldom aid us in deciding upon the area involved, as these cases usually present themselves to the aural surgeon after the mastoid cells have been thoroughly obliterated and all foci of diseased bone about the middle ear removed. In cases which come under observation late, and where the mastoid has not been operated upon, this operation should constitute the initial step of the procedure. If the dura is exposed either by caries of the tympanic roof or of the inner table of the skull over the lateral sinus, any evidences of meningitis which may be present will be discovered at the time of the primary operation. In the absence of any evidence of disease of the dura in these localities, or where the dura has not been exposed at the time of the mastoid operation and where the symptoms of meningitis develop, the surgeon should do an exploratory craniotomy, entering the skull just above the external auditory meatus. This is best done by dividing the soft parts by means of a curved incision from a point one half inch behind the posterior border of the meatus, extending it upward over the top of the ear to a point one inch and a half above the superior margin of the auricle, and then curving downward and forward to a point one half inch behind the external angular process of the frontal bone. All the structures are divided down to the bone, bleeding points secured by means of clamps, and the lower flap, including the auricle, pushed downward by means of the periosteal elevator, so as to bare the skull throughout the entire extent of the cutaneous incision. If more room is needed, the upper flap may also be elevated by means of the periosteal elevator. The skull is then opened by means of the chisel about half an inch above and a quarter of an inch in front of the centre of the external auditory canal, this being the thinnest part of the squamous plate, and therefore a region at which the cranial cavity can be most easily opened. As soon as the opening has been made in the skull, this opening is rapidly enlarged upward, backward, and downward by means of the rongeur forceps until the opening measures at least one inch in the vertical diameter and one and a quarter inches in the longitudinal diameter. The bone is removed below sufficiently to allow the director or a flat, narrow retractor to be passed along the roof of the tympanum as far almost as the apex of the pyramid. In some cases the finger can be introduced although this frequently is not possible, owing to adhesions. Several cases have come under my observation where a complete mastoid operation with this free exposure of dura has been sufficient to effect a cure without other interference. If the dura is found involved—and frequently this is the only condition we find—it is well to turn down a dural flap. In order to effect this a curved incision is made through the dura from in front upward and backward, so as to leave the dural flap attached below. This flap is turned down and the surface of the brain exposed. In cases of advanced meningitis we find the pia very much injected and considerable fluid in the arachnoid space. We find reports of a number of cases in which the exposure of the dura and the incision of this membrane have been followed by complete recovery. This measure is, therefore, advised by Boenninghaus.*

Where the brain substance bulges through the dural wound, it is always wise to make an incision through the brain substance into the lateral ventricle, so as to relieve any accumulation of fluid which may be present. It will be remembered, in speaking of serous meningitis, that one of the forms of this disease is characterized by an accumulation of fluid in the lateral ventricles. The evacuation of this fluid by incision through the brain substance is by no means new, having been advocated a number of years ago for the relief of chronic hydrocephalus in infants. In cases of acute serous meningitis, however, dependent upon a middle-ear suppuration, this procedure is certainly indicated as a means of relieving the intracranial pressure.

In order to enter the lateral ventricle, in the region above described, either a large aspirating needle attached to a syringe, or, preferably, a narrow, straight knife, sharp-pointed, should be introduced into the brain substance, forward and inward and slightly upward, for a distance of about one and three quarters to two and one-half inches. In case the ventricles are filled with fluid, as the result of a meningitis, fluid will be obtained before the knife has entered this distance, owing to the fact that the cavity of the ventricle is much dilated by the presence of the serum. If an excess of ventricular fluid is found, it is well to insert a strip of sterile rubber tissue into the cavity in order to secure drainage. Some authors prefer to simply remove the fluid from the ventricle by tapping with a large needle, instead of evacuating it by free incision. Since infection of the meninges frequently occurs through a previous infection of the labyrinth, the infection following the course of the auditory nerve trunk through the internal auditory meatus, Neumann has advised the exposure of the internal auditory meatus and incision of the dura in this neighborhood. In this procedure the labyrinth is first extirpated by the Neumann method. (See plate xvii.) The dura is then exposed deeply beneath the vestibule by carefully removing the bone until the internal auditory meatus is reached when the dura is incised and a folded rubber drain inserted. In order to render this drainage more complete, the author has insisted in these cases upon the complete removal of the superior semicircular canal. This exposes the internal auditory meatus perfectly not only posteriorly, but also superiorly, and admits of a free incision of the dura. The author has had only very indifferent success in following this procedure.

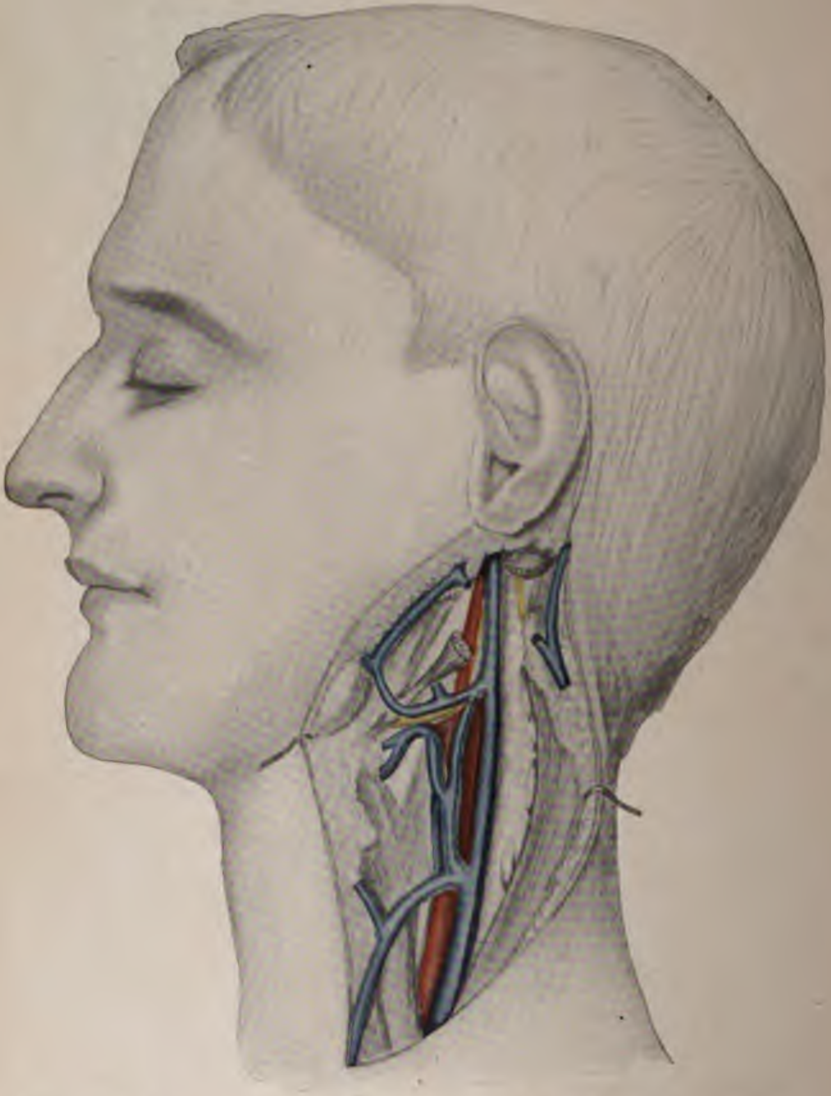
---

* Meningitis serosa acuta, Wiesbaden, 1897, p. 65.

Another method of treating this condition is by lumbar puncture, first advised by Quincke. This consists in entering the spinal canal either between the fourth and fifth lumbar vertebræ, or between the fifth lumbar and first sacral vertebræ. The procedure is not very painful, and can be performed without the induction of local anæsthesia. In nervous patients it is wise to anæsthetize the operative field either by the subcutaneous injection of a few minims of a sterilized four-per-cent solution of cocaine, or by freezing the parts with a spray of ethyl chloride. In order to perform this operation, the back of the patient should be sterilized for a distance of four inches on each side of the median line, from a point just below from below does not occur, it indicates that the clot has extended downward through the bulb and into the internal jugular vein, from which point it is continually infecting the general circulation by the venous tributaries which enter the internal jugular below the base of the skull. If, however, the sinus is completely plugged at the bulb, systemic infection can scarcely take place from any point above the jugular bulb, consequently it is well not to curette out the upper portion of the wound too thoroughly or too persistently. If there is a soft clot in this region and it can be broken down easily by means of the curette, free hæmorrhage being established, then the clot should be broken down. If, however, the clot seems very firm and extensive, it is quite possible that it may extend well out toward the torcular, and that its upper portion may be non-infectious. It would, therefore, be unwise to disturb such a clot, as further decomposition would probably be avoided by properly curetting and packing the sinus wound with iodoform gauze. While we know from autopsies that infection through the opposite veins, through the torcular Herophili, does occur, such cases are so uncommon as to warrant their being practically disregarded—certainly at the time of primary operation, and the aim of the surgeon should be to prevent infection from the sinus through the jugular of the same side.

In cases where there is evidence of profound systemic infection, the surgeon should remember that the mere fact that free hæmorrhage occurs from below after opening the sinus does not indicate necessarily that the jugular has not been involved. As the channel through which infection of remote parts of the body occurs is a continuation of the lateral sinus—that is, the internal jugular vein—it often becomes necessary to cut off this large afferent channel in order to prevent the further absorption of septic material. If the case has been under observation for some time, it is possible that the surgeon may make a diagnosis of extension of the thrombus into the internal jugular. Such a diagnosis would depend upon great temperature fluctuations—that is, a temperature rising suddenly to 105° or 106°, and then falling spontaneously in a few hours to normal or subnormal. In addition to this symptom, there would be other evidences of poisoning, such as asthenia, emaciation, and profuse perspiration. Locally, it is sometimes possible, in cases where the clot has extended into the internal jugular vein, to make out, upon palpating the neck, a tense, cord-like band fol-

PLATE XV.



DISSECTION OF INTERNAL JUGULAR VEIN, SHOWING FREE VENOUS ANASTOMOSIS ON THIS SIDE AS CONTRASTED WITH PLATE XIV.

(Opposite side of same subject, author's dissection.)

lowing the course of the internal jugular. Many authors seem to lay considerable stress upon this point; personally, I have never observed this physical sign. We must remember that the upper portion of the internal jugular vein lies deeply, the vessel being covered by the digastric muscle, deep cervical fascia, the parotid gland, the platysma, and the integument. Bearing in mind the fact that the deep lymphatic channels of the neck, like the deep cervical fascia, follow the general course of the vessels, and remembering how quickly these glands become involved whenever any septic process occurs in the adjacent region, it is at once evident that a thrombus in the internal jugular may hardly be recognized by palpating the neck until this thrombus had extended well down the lumen of the vein; certainly, below the level of the larynx. In a number of my own cases there has been a hard, brawny swelling in the region of the parotid gland and along the anterior border of the sterno-mastoid muscle. In some cases I have been able to detect a tender point just at the anterior border of the muscle and just behind and above the angle of the jaw. The cord-like feeling, however, which is said to be indicative of the presence of the thrombus in the internal jugular vein, I have never observed. General tumefaction, then, and a tenderness along the anterior border of the sterno-mastoid muscle, together with great fluctuations in temperature, would lead the surgeon to suspect in any given case of purulent otitis, with or without mastoid involvement, that the infecting process had possibly extended from the sinus into the vein. I believe, however, that an absolutely certain diagnosis can only be made at the time of operation. If, when the lateral sinus is explored in the manner detailed in the preceding pages, free hæmorrhage does not occur from below, or even if there is considerable hæmorrhage from the lower end of the vein, if the surgeon finds the tissues just behind the angle of the jaw brawny and evidently infected, and if the fluctuations in the temperature have been well marked, he should not be content with clearing out the thrombus from the lateral sinus alone, but should immediately proceed to cut off the return circulation through the internal jugular vein. Ballance was the first to recognize the importance of this procedure. But in the earlier operations a ligature was simply applied to the vein below the point at which the thrombus was found. In some instances, the vein was opened and the blood channel washed out with an antiseptic solution injected upward until the solution flowed out through the opening in the lateral sinus above. For a number of years surgeons have pursued the plan of completely excising the infected vein. The operation is best performed as follows: After the sinus has been explored and curetted, in the manner already described, the shoulders of the patient are elevated upon a pillow, thus rendering the sterno-mastoid muscle tense. The neck is then cleansed from the clavicle to the mastoid, the tissues being manipulated very carefully in order to prevent the breaking down of any clot which may be present in the jugular and the detachment of an embolus from any thrombus which may lie in the vein. An incision is then made from the sternal attachment of the sterno-mastoid muscle upward to the tip of the mastoid, the incision following the anterior border of the sterno-cleido-mastoid muscle. The integument is first divided, and the surgeon then observes the oblique fibres of the platysma. The platysma varies in thickness considerably in different individuals. At the lower part of the neck the muscle is very thin, while above it may be quite thick. As soon as the integument and the platysma are divided, the anterior border of the sterno-mastoid muscle comes into view. By means of retractors, the margins of the wound are separated, the sterno-mastoid being pulled backward. The deep fascia of the neck is then seen, and upon opening this the sheath of the vessels is found to lie immediately beneath the anterior border of the muscle. The common sheath of the vessels, it will be remembered, contains the common carotid artery, the internal jugular vein, and the pneumogastric nerve. The vein always lies to the outer side of the artery, low down in the neck, lying somewhat in front and to the outer side, while higher up in the neck it crosses the carotid just about at the point of bifurcation of this vessel into the external and internal carotid arteries. It then follows the course of the internal carotid artery, and at the base of the skull lies on the outer side and slightly behind this vessel. The pneumogastric nerve lies between the vein and the internal carotid above and between the vein and the common carotid below. It also lies a little behind these vessels. After the sheath of the vessels has been opened, the vein is easily recognized by its dark-bluish color. Firm pressure at the root of the neck will cause the vein to fill with blood, and it can thus be more easily recognized. The first step of the operation is to clear the vein as thoroughly as possible from the sheath. This is best done by some blunt instrument, such as the handle of the scalpel or the closed blades of a pair of blunt-pointed scissors, the connective tissue overlying the vein being raised cautiously by a pair of forceps and torn along the axis of the vessel by means of the blunt scissors or by means of a director; care is necessary in order to thoroughly separate the vessel from the pneumogastric nerve. Although the nerve lies behind the vessel, it is sometimes adherent to the sheath of the internal jugular. Unless care is taken to recognize the nerve at the time of the dissection, it may be included in a ligature passed around the vein. The vein is best cleared by dissecting along its posterior and postero-internal aspect. All of the tributary vessels come off from the anterior aspect of the vein and practically no tributaries are met if the dissection is carried along the posterior wall. The vein should be exposed sufficiently low down in the neck so that two ligatures may be passed about it, below the point to which the clot extends. In some cases, I have followed the vein almost to the innominate. After the vein has been thoroughly exposed, two ligatures are passed about the vessel as low down in the neck as necessary. These ligatures are tied, and the vein is divided between them. The entire vein is then carefully dissected out, all tributary branches being divided between two ligatures as the dissection is continued from below upward. The number of tributaries requiring ligation will vary in individual cases. The branch which always requires ligation is the common trunk of the temporal and facial veins which joins the internal jugular at a point just about the level of the hyoid bone. Occasionally the thyroid and laryngeal branches must be divided between two ligatures as we proceed from below upward before this large trunk is reached. In many instances, however, the thyroid, laryngeal, and lingual branches are so small as to entirely escape observation. When the common trunk of the lingual, temporal, and facial is reached, care must be taken to separate this trunk cautiously from the underlying tissues and to divide it between two ligatures. In two of my cases I have found a clot in the internal jugular extending down as far as the point where the facial vein joins the internal jugular and systemic infection was undoubtedly occasioned by the carrying into the general circulation of portions of this clot by the blood current entering the jugular through the facial and temporal veins. This large branch must therefore be carefully secured and divided between two ligatures. The internal jugular is then followed upward as high as possible, is surrounded by two ligatures and divided between them. As the common trunk of the temporal and facial vein is the last large branch given off from the vein, it is not necessary to follow the vessel completely to the base of the skull. It may be divided with perfect safety at a point three quarters of an inch above where the facial vein enters the internal jugular. I do not think it advisable to attempt to wash out any clot which may be present by the injection of fluid into the upper extremity of the vein. The small segment of vessel lying between the point of ligation and the opening in the lateral sinus can scarcely afford any opportunity for systemic infection. I believe there is much more danger of forcing septic material into the general circulation through the inferior petrosal sinus if fluid is injected into the upper portion of the vein, than if the operation is terminated simply by a ligation of the vessel. After the operation has been concluded the wound in the neck should be flushed with a warm saline solution, and the margins of the wound united by means of interrupted sutures, preferably of silk. The upper angle of the wound should be left open and a packing of iodoform gauze inserted. The opening made in the sinus at the early part of the operation should then receive attention. A strip of iodoform gauze should be inserted at the upper angle of the wound between the sinus and its bony covering, thus occluding the sinus at this point. The lower extremity of the sinus wound may be packed with iodoform gauze inserted directly into the sinus. If the upper extremity of the sinus wound is not treated in this manner, persistent hæmorrhage is apt to follow upon the removal of the packing. The procedure described obliterates the upper portion of the sinus by obliteration of its lumen. The entire mastoid wound should then be dressed in the usual way, care being taken to separate the mastoid antrum from the open sinus by means of gauze packing. Out of fifty-seven cases operated on forty were cured and seventeen died. The causes of death were as follows: one of hæmorrhage into the spinal canal, one of pyæmia (late operation), three of pneumonia beginning before operation, one of diabetes, one of gangrene of the lung, one of gangrene of the neck, and one of malnutrition. In eight cases the cause of death was not recorded.

CHAPTER XXXI.

OTITIC MENINGITIS.

In instituting operative procedures for a meningitis, the rational symptoms seldom aid us in deciding upon the area involved, as these cases usually present themselves to the aural surgeon after the mastoid cells have been thoroughly obliterated and all foci of diseased bone about the middle ear removed. In cases which come under observation late, and where the mastoid has not been operated upon, this operation should constitute the initial step of the procedure. If the dura is exposed either by caries of the tympanic roof or of the inner table of the skull over the lateral sinus, any evidences of meningitis which may be present will be discovered at the time of the primary operation. In the absence of any evidence of disease of the dura in these localities, or where the dura has not been exposed at the time of the mastoid operation and where the symptoms of meningitis develop, the surgeon should do an exploratory craniotomy, entering the skull just above the external auditory meatus. This is best done by dividing the soft parts by means of a curved incision from a point one half inch behind the posterior border of the meatus, extending it upward over the top of the ear to a point one inch and a half above the superior margin of the auricle, and then curving downward and forward to a point one half inch behind the external angular process of the frontal bone. All the structures are divided down to the bone, bleeding points secured by means of clamps, and the lower flap, including the auricle, pushed downward by means of the periosteal elevator, so as to bare the skull throughout the entire extent of the cutaneous incision. If more room is needed, the upper flap may also be elevated by means of the periosteal elevator. The skull is then opened by means of the chisel about half an inch above and a quarter of an inch in front of the centre of the external auditory canal, this being the thinnest part of the squamous plate, and therefore a region at which the cranial cavity can be most easily opened. As soon as the opening has been made in the skull, this opening is rapidly enlarged upward, backward, and downward by means of the rongeur forceps until the opening measures at least one inch in the vertical diameter and one and a quarter inches in the longitudinal diameter. The bone is removed below sufficiently to allow the director or a flat, narrow retractor to be passed along the roof of the tympanum as far almost as the apex of the pyramid. In some cases the finger can be introduced although this frequently is not possible, owing to adhesions. Several cases have come under my observation where a complete mastoid operation with this free exposure of dura has been sufficient to effect a cure without other interference. If the dura is found involved—and frequently this is the only condition we find—it is well to turn down a dural flap. In order to effect this a curved incision is made through the dura from in front upward and backward, so as to leave the dural flap attached below. This flap is turned down and the surface of the brain exposed. In cases of advanced meningitis we find the pia very much injected and considerable fluid in the arachnoid space. We find reports of a number of cases in which the exposure of the dura and the incision of this membrane have been followed by complete recovery. This measure is, therefore, advised by Boenninghaus.*

Where the brain substance bulges through the dural wound, it is always wise to make an incision through the brain substance into the lateral ventricle, so as to relieve any accumulation of fluid which may be present. It will be remembered, in speaking of serous meningitis, that one of the forms of this disease is characterized by an accumulation of fluid in the lateral ventricles. The evacuation of this fluid by incision through the brain substance is by no means new, having been advocated a number of years ago for the relief of chronic hydrocephalus in infants. In cases of acute serous meningitis, however, dependent upon a middle-ear suppuration, this procedure is certainly indicated as a means of relieving the intracranial pressure.

In order to enter the lateral ventricle, in the region above described, either a large aspirating needle attached to a syringe, or, preferably, a narrow, straight knife, sharp-pointed, should be introduced into the brain substance, forward and inward and slightly upward, for a distance of about one and three quarters to two and one-half inches. In case the ventricles are filled with fluid, as the result of a meningitis, fluid will be obtained before the knife has entered this distance, owing to the fact that the cavity of the ventricle is much dilated by the presence of the serum. If an excess of ventricular fluid is found, it is well to insert a strip of sterile rubber tissue into the cavity in order to secure drainage. Some authors prefer to simply remove the fluid from the ventricle by tapping with a large needle, instead of evacuating it by free incision. Since infection of the meninges frequently occurs through a previous infection of the labyrinth, the infection following the course of the auditory nerve trunk through the internal auditory meatus, Neumann has advised the exposure of the internal auditory meatus and incision of the dura in this neighborhood. In this procedure the labyrinth is first extirpated by the Neumann method. (See plate xvii.) The dura is then exposed deeply beneath the vestibule by carefully removing the bone until the internal auditory meatus is reached when the dura is incised and a folded rubber drain inserted. In order to render this drainage more complete, the author has insisted in these cases upon the complete removal of the superior semicircular canal. This exposes the internal auditory meatus perfectly not only posteriorly, but also superiorly, and admits of a free incision of the dura. The author has had only very indifferent success in following this procedure.

---

* Meningitis serosa acuta, Wiesbaden, 1897, p. 65.

Another method of treating this condition is by lumbar puncture, first advised by Quincke. This consists in entering the spinal canal either between the fourth and fifth lumbar vertebræ, or between the fifth lumbar and first sacral vertebræ. The procedure is not very painful, and can be performed without the induction of local anæsthesia. In nervous patients it is wise to anæsthetize the operative field either by the subcutaneous injection of a few minims of a sterilized four-percent solution of cocaine, or by freezing the parts with a spray of ethyl chloride. In order to perform this operation, the back of the patient should be sterilized for a distance of four inches on each side of the median line, from a point just below the free border of the ribs to the tip of the coccyx. The patient should be placed upon the side with the trunk flexed strongly. In this way, the lumbo-sacral muscles are put upon the stretch. A rather long aspirating needle, about three inches in length and of a diameter of about one millimetre, is then plunged through the soft tissues of the back, either directly in the median line, or, preferably, slightly to the left of the spinous processes of the vertebræ, either between the fourth and fifth lumbar spines or between the fifth lumbar spine and the first sacral vertebra. If the puncture is made to the left of the median line, the needle should pass upward and inward to the right. If made directly in the median line, it should pass inward and slightly upward. In children, the puncture, according to Quincke, is easily made in the median line; in adults, it is best to introduce the needle about a finger's breadth to the left of the spinous processes of the vertebræ. There is no danger of injuring the spinal cord at this point, because, as will be remembered, the cord does not extend below the level of the first lumbar vertebra, the spinal canal in this region consisting of the lumbar sac, which contains the *cauda equina*. This operation should only be undertaken under the most strict aseptic precautions, as otherwise infection of the cerebro-spinal fluid might easily occur. As soon as the spinal canal has been entered the operator will be cognizant of the fact by a flow of limpid or slightly turbid fluid from the canula. If a meningitis is present and there is increased pressure of the cerebro-spinal fluid, the escape of fluid from the canula will be very free. It is not wise, under any conditions, to draw off more than one hundred cubic centimetres of the fluid, and it is better not to draw this full amount at once, even when the pressure is high, but to cause the flow to intermit occasionally by closing the canula for a few moments, thus preventing any sudden alteration of intracranial pressure.

As a diagnostic measure lumbar puncture is of great value. Where the cerebrospinal fluid is under increased pressure, this will be indicated by the force with which the fluid is ejected from the needle. Normally cerebrospinal fluid flows drop by drop. If the fluid issues in a stream and is projected with considerable force from the needle, this is a pathogenic condition and is significant. The exact amount of pressure is unimportant. The cytological examination of the fluid is of great importance. Normally the fluid is alkaline in reaction, reduces Fehling's solution, does not contain globulins, excepting in very small quantities, the cell count is from zero to ten, and the fluid is sterile. In meningitis the alkaline reaction is lost, and the fluid becomes acid. Fehling's solution is not reduced, the globulin test is positive, and the cell count is greatly increased. Observation has shown that an increase in the globulin test may be caused simply by exposure of the dura at the time of operation, or by its previous involvement by a pathogenic process. Naturally, the presence of any pathogenic bacteria in the spinal fluid upon culture is absolutely indicative of meningeal infection. The specific gravity of the fluid withdrawn is, in serous meningitis, very little above the normal standard. In purulent meningitis, however, it rises to a point considerably above the normal standard. In purulent meningitis also, the spinal fluid contains from eight to nine per cent of albumin, against a normal percentage of one fiftieth of one per cent to one half of one per cent.

As a diagnostic measure lumbar puncture is of great value. It has also proven itself of value as a therapeutic measure in cases where the cerebrospinal fluid does not show the presence of bacteria, in other words where we are dealing with a serous meningitis. In these cases the clearing out of the original focus of infection within the mastoid and the exposure of a large area of dura followed by repeated lumbar punctures to reduce the intracranial pressure constitute therapeutic measures of undoubted value.

Epidural Abscess.—When there is pus between the dura mater and the osseous wall of the cranium it is only necessary to perforate the skull to evacuate the fluid. The decision as to the location of such an abscess always is a matter of conjecture, and it is well to remember that, out of a series of cases, the most usual location has been either in the posterior or in the middle cranial fossa in the order named. The operative technique consists in the removal of the inner table of the skull, over the site of the mastoid opening, extending it as much as is necessary to expose the dura in the posterior fossa. A probe is then inserted between the meninges and bone and passed gently in every direction, to discover, if possible, the location of the purulent focus. Failing in this, the middle cranial fossa should be explored; this may be done by enlarging the original opening by means of the rongeur. Owing to the thickness of the skull in this region, it is wiser to perforate a second time than to enlarge the previous opening. For this purpose the cutaneous incision is extended, in the same manner as previously described under Operative Treatment of Otitic Meningitis. After the squama has been exposed, the middle cranial fossa is entered, and the entire tympanic roof and extradural space of the middle fossa is carefully explored by means of the probe, in order to discover any extradural collection of pus. If such a collection is found, it is evacuated, and the opening in the skull is enlarged so as to admit of a thorough exploration of the cavity in every direction. It is unwise, under these circumstances, however, to remove the bone beyond the limits of the abscess. We find, in these cases, that the purulent collection is walled off from the general cranial cavity by firm adhesions between the dura and the skull. If, after evacuating the abscess, the surgeon persists in the removal of bone until actual normal dura is encountered, these adhesions are broken down and there is danger of infecting the previously healthy dura and of setting up a purulent meningitis. The line of adhesion should, therefore, be carefully preserved, but enough bone should be removed to allow the entire abscess cavity to be explored by means of the finger. After the pus has been evacuated, the abscess cavity should be wiped out with either sterile sponges or with sponges moistened in a 1-5,000 bichloride of mercury. If the cavity is large and the discharge thick, it may be well to irrigate the cavity with a warm solution of mercury, of a strength of 1-5,000. After this irrigation the abscess cavity is packed with iodoform gauze. The anterior portion of the incision through the skin is closed by means of one or two sutures of silkworm gut. The original mastoid wound is packed in the usual manner, and completely isolated from the opening into the cranial cavity in the middle fossa by means of a firm packing of iodoform gauze introduced between the packing in the abscess cavity and the packing in the mastoid antrum.

The separation of the epidural abscess cavity from the mastoid wound by means of firm gauze packing should be looked upon as a matter of great importance, not only in applying the dressing immediately after the operation, but also at each subsequent dressing, until the walls of the cavity are covered with healthy granulation tissue. If this is not done, infection of the exposed dura may occur, resulting in a general purulent meningitis. If the abscess is large, it is well to change the dressing every day so as to keep the surrounding tissues as free from pus as possible and to thus prevent the infection of the dura adjacent to the abscess.

In cases in which the later sinus lies in the floor of the abscess cavity, and is covered with granulation tissue, the operator should not forcibly curette away these granulations. This tissue forms a barrier against the infection of the underlying sinus from the pus in which it is bathed, and its forcible removal may be followed by infection of the sinus, and development of a sinus thrombosis. Careful palpation of the sinus with the finger will usually enable the operator to determine the presence of a clot in the lumen of the vessel. It is often wise in doubtful cases to follow the course of the sinus for a short distance beyond the limits of the abscess cavity, either in an upward or downward direction, according to the location of the abscess, if the size of the cavity does not expose the sinus for a distance of, at least, three quarters of an inch. Pressure should next be applied to the upper exposed portion of the vessel close to the bony margin of the wound. If no thrombus is present, pressure above will cause the vessel to collapse below. The pressure above should next be removed and the sinus compressed at the lowest point of its exposure. If the lumen of the vessel is free, it will immediately fill with blood to the point at which pressure is applied.

If, after applying these tests, the operator is in doubt as to the presence of a thrombus, he may then remove the granulations from the surface of the vessel, cleanse the abscess cavity thoroughly by the gentle use of the curette, and then open the sinus in the manner already described on a previous page, for exploration of the lateral sinuses in doubtful cases. If a thrombus is found, the condition should be dealt with in the manner already detailed in a previous chapter. It will be seen, therefore, that in no instance should granulation tissue over the sinus be removed until the operator has decided to make an exploratory opening in that vessel and to then subsequently shut it off entirely from the general circulation by means of a firm packing of iodoform gauze.

The results of operative treatment in epidural abscess are extremely favorable. The author's statistics have already been given on page 472.

CHAPTER XXXII.

CEREBRAL AND CEREBELLAR ABSCESS.

WHERE localizing symptoms indicative of the presence of a collection of pus within the brain substance are evident, the surgeon has then precise indications as to what portion of the cranial cavity shall be entered for the evacuation of this purulent collection. In most cases of cerebral abscess arising from suppurative otitis, however, localizing symptoms are rare. The surgeon is most frequently in doubt as to whether the infected area within the brain lies in the cerebrum or in the cerebellum. In certain cases, especially where the left ear is affected, causing involvement of the left side of the brain, the aphasic symptoms enable the surgeon to make a fairly accurate diagnosis. Symptoms of loss of power in the upper and lower extremities are seldom met with. When, therefore, the right ear is involved, practically no definite localizing symptoms are present.

As the patient presents himself, the surgeon has, then, no positive evidence of the location of the intracranial infection. He has simply the history of a suppurative process within the middle ear which has lasted for a considerable period of time. The general appearance of the patient is indicative of some severe constitutional infection, but an examination of the thoracic and abdominal viscera show the parts to be perfectly normal. In the more advanced cases the patients are in a state of hebetude or even in a state of coma. The surgeon has nothing whatever to guide him except the fact that there is a chronic suppurative otitis upon one side. All operative procedures must, therefore, be of an exploratory character, and the opening in the cranial cavity must be large enough to enable the operator to investigate the entire cranial contents rapidly. We know from autopsies performed upon cases of this kind which have terminated fatally, that the most frequent site of an abscess, due to middle-ear suppuration, is in the temporo-sphenoidal lobe, the infection taking place directly through the roof either of the mastoid antrum or of the tympanic vault. The second favorite site is abscess of the cerebellum, infection occurring through the posterior wall of the lateral sinus. In all exploratory operations upon the brain, when the primary infection is an otitis, the first step should be to rapidly enter the mastoid antrum and to expose the roof of the tympanum and of the mastoid antrum. The cutaneous incision should then be extended upward and forward to the external angular process of the frontal bone. The lower flap is then pushed downward and the squama uncovered. It is not wise to elevate the periosteum of the upper flap unless it is found subsequently that a larger opening in the cranial cavity is necessary. The mastoid wound having been packed with gauze, the surgeon then enters the cranial cavity at a point just above the external auditory meatus. The squama is extremely thin in this region, and the wall of the skull is easily broken through by a few strokes of the chisel. This opening should be enlarged in every direction by means of the rongeur forceps, the aperture being gradually extended upward and backward until an opening at least an inch in diameter has been made. A probe or director is then cautiously introduced betweeen the dura and the upper surface of the petrous pyramid. If care is taken, the dura may be separated from the superior surface of the pyramid and the finger passed along its bony surface. If the dura appears normal through the opening already made, it is then wise to continue this opening downward and backward by removing the floor of the middle fossa over the region of the tegmen tympani and tegmen antri. This exposes the lower surface of the temporo-sphenoidal lobe. If, when the mastoid was opened an opening was discovered by means of the probe either through the tegmen tympani or the tegmen antri, the surgeon will naturally rapidly enlarge the exploratory opening in the cranium by removal of the tegmen tympani and tegmen antri by means of the rongeur forceps, thus making the exploratory opening continuous with the external auditory meatus and the vault of the tympanum. In this way, an exceedingly large dural area is exposed, and in that region where infection is most likely to occur. It is seldom that either inspection or palpation of the dura will give any indication as to the location of the abscess. Where a softened dural area is found, the surgeon naturally would make an incision through the dura and enter the brain substance at this point in the hope of evacuating the pus. If no such indication is present, however, the next point is to reflect a dural flap before incising the brain substance. I am strongly averse to making incisions into the cerebral substance before reflecting a dural flap, although I know that this is the practice of many eminent surgeons. The dural flap is best formed by making a curvilinear incision through the dura, the convexity of the flap being downward, corresponding approximately to the *linea temporalis*. This flap is reflected upward and the knife is then plunged into the brain substance, first in a direction upward, backward, and inward. If this puncture is followed by a discharge of pus along the blade of the knife, a free incision is made into the brain substance, care being taken that the knife follow along the line of a convolution, rather than across it, in order to avoid the wounding of important vessels which may give rise to troublesome hæmorrhage. For the same reason, the knife should always be plunged into the convexity of a convolution and not into the fissure between the two convolutions. It most frequently happens that the first incision will fail to reveal the presence of pus. The surgeon must then carefully introduce the knife in various directions, downward, forward, and inward; downward, backward, and inward; and upward, forward, and inward; he should not be satisfied to rely upon puncture alone, but should incise the brain substance thoughout the entire depth of the puncture for a distance of at least half an inch. It sometimes happens that the pus from the cerebral abscess is so thick it will not flow along the knife unless a rather free incision is made, and although the abscess cavity may have been entered by an exploring instrument, the presence of pus will be unrecognized unless the incision is sufficiently extensive to allow of the evacuation of the thick, broken-down cerebral substance, which makes up the contents of the abscess. It is also wise, in case an incision in various directions does not reveal pus, to cautiously introduce a grooved director along the line of incision in the hope that a pent-up collection of pus deep in the cerebral substance may be recognized by the escape of pus along the groove in the director. As soon as the abscess cavity has been entered, as indicated by a flow of pus, a small narrow bladed, delicate retractor may be passed along the director. The director is then removed and a second retractor passed parallel to the first instrument. Separation of these retractors opens the abscess cavity widely, and permits of free evacuation of its contents as well as its subsequent exploration under illumination and its subsequent packing. The exploring finger may also be introduced into the abscess cavity, and the introduction of the finger is frequently advisable. Digital exploration should, however, be exceedingly gentle.

As a rule, I do not think it wise to irrigate a cerebral abscess at the time of primary operation. I can easily conceive of some cases in which irrigation may be advisable. I think, however, that the introduction of fluid at the time of primary operation is rather a disadvantage. It is true that by free irrigation much of the necrotic tissue within the abscess cavity may be washed away. This necrotic tissue, however, will be expelled equally well by the intracranial pressure in the course of twenty-four hours if the abscess cavity is filled by a fairly firm gauze packing. It has always seemed to me that in washing out the cavity of a brain abscess at the time of primary operation there was danger of washing away some of the healthy brain tissue which might be exposed or of infecting the deeper parts through the current of fluid introduced. If great care is exercised, this objection would hardly hold. Whenever irrigation is practiced the fluid should be introduced through a small canula at low pressure, while the avenue for the return current should be large. Experience, however, teaches us that necrotic tissue is quite well expelled in the course of a few hours by the intracerebral pressure, and, on general principles, it seems wise to interfere as little as possible with the brain substance.

Dr. Whiting, of this city, has perfected an ingenious instrument known as the encephaloscope, by which a clear view of the interior of a brain abscess can be obtained. This instrument is an ear speculum of large size, the lumen of which is completely filled by an obturator. The end of the obturator is rounded, so as to admit of the introduction of the speculum, without injuring the delicate brain tissue. After the abscess cavity has been opened, the encephaloscope, with the obturator in position, is cautiously introduced into the incision, and the obturator withdrawn. By the aid of reflected light the surgeon can then inspect the entire abscess cavity, and can also see to thoroughly cleanse this cavity under ocular inspection. If multiple abscess is present, he will be able to discover that the primary incision has not caused a complete evacuation of all the pus within the brain, and will, in some instances, be able to open up these other foci of infection under direct inspection. The packing of the abscess cavity is much facilitated by the use of this instrument. Dr. Whiting reports four cases of temporo-sphenoidal abscess operated upon successfully, and attributes his success in no small degree to the use of this device.*

After an abscess has been evacuated and appropriate drainage instituted, care should be taken to isolate the adjacent brain substance and the meninges from the abscess cavity by means of gauze packing. The middle ear and antrum should also be packed off separately to prevent any infection of healthy brain tissue which may lie immediately adjacent to infected areas within the middle ear. The anterior angle of the wound should be closed with sutures, either of silkworm-gut or of strong silk, to prevent scarring as far as possible. The entire operative field is then covered with the usual antiseptic dressing and a bandage applied. The first dressing should be made about twenty-four hours after the operation. At this dressing I think it wise to remove the drain or packing

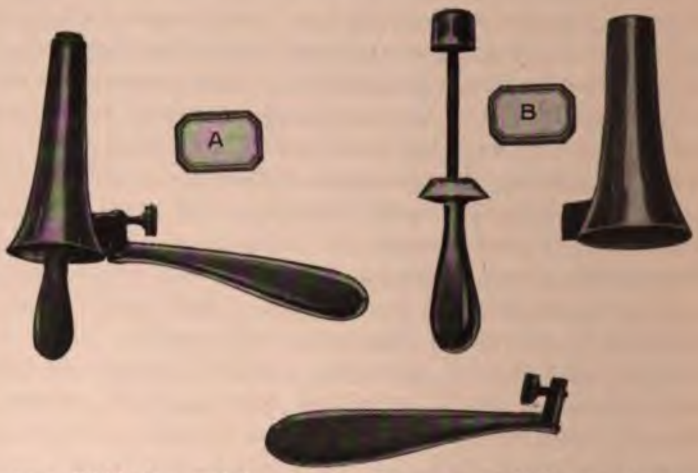


FIG. 157.—Whiting's encephaloscope: A, Instrument ready for introduction; obturator is in position and the handle is attached to the speculum. B, Obturator, speculum, and handle separated.

---

* According to my experience the encephaloscope affords less information than can be gained by the use of retractors or the exploring finger.

from the abscess cavity, and to again introduce the retractors or finger into the abscess. This is usually followed by the discharge of considerable pus, although, apparently, the packing has filled every recess within the abscess cavity. I think that such exploration carefully conducted at the first and subsequent dressings, for a period of at least a week after the operation, is of importance to avoid the possibility of the forming of secondary small abscesses in the immediate proximity of the site of primary cerebral infection. This introduction of the finger is, of course, somewhat painful, but causes far less suffering than would be imagined. If the abscess is large and deep-seated, I have found it wise at the first dressing to substitute the rubber drainage tubes for the gauze packing or cigarette drain. I usually introduce two tubes into the cavity side by side, and assure myself that the tubes are patent when in position by irrigating the cavity gently with a warm saline solution. The wound is then packed in the manner indicated and described in the primary operation. Where the discharge from the abscess is foul, it is usually wise to dress the case every twenty-four hours for a period of ten days after the operation, at the end of which time the dressing may be made less frequently.

Considerable latitude of opinion exists as to the method of dressing these cases. Some recommend lining the entire cavity with perforated rubber tissue and packing the *cul-de-sac* thus formed with either sterile or iodoform gauze. Others introduce wicks of gauze saturated with either iodoform or a mixture of boric acid and iodoform. If the surgeon is perfectly certain that the abscess cavity has been rendered thoroughly sterile, it is quite permissible, as Macewen states, to remove all drainage tubes at the end of twenty-four to forty-eight hours, and to allow the walls of the abscess to come together. If the surgeon does not care to do this, an absorbable bone drainage tube may be inserted, thus keeping up drainage for a few days, and as the tube is absorbed the walls of the abscess cavity come together and the parts return to their normal condition.

In dealing with abscesses of otitic origin, however, it seems to me that the surgeon runs considerable risk in assuming that the entire abscess cavity has been rendered aseptic, and it is certainly wiser, in the majority of cases, to keep the drainage tube in position for a sufficient length of time to be perfectly certain that all infectious material has been evacuated from the cerebral substance. Where an abscess has been evacuated, the edges of the dural flap should not be approximated, as such a procedure would favor the retention of pus either within the abscess cavity, or infection of the arachnoid space. This latter accident should be guarded against by the use of a firm packing along the margins of the dural opening so as to cause adhesion between the dura and pia mater in the neighborhood of the abscess, thus obliterating the subdural space over this area. In cases where examination of the exposed dura shows no indication as to the route of infection the best procedure seems to be to expose a large area of dura over the temporosphenoidal lobe, and to divide the dura by crossed incisions, and to pack between the dura and the underlying brain. This constitutes a decompression operation, and the packing will cause a walling off of the subdural space within six to eighteen hours. The pressure symptoms will be relieved by the decompression. The relief of superficial pressure will favor the passage of the pus along the line of least resistance, that is toward the decompressed area, while the packing about the margins of the dural opening will obliterate the subdural space in this region and prevent a secondary meningitis when the brain abscess is subsequently evacuated through the exposed area. In from twelve to twenty-four hours after this decompression the brain may be explored with the director and the abscess evacuated.

If one of the lateral ventricles is entered in making an exploratory incision, ventricular fluid will be evacuated, and as in all intracranial diseases attended with venous hyperæmia the ventricular fluid is increased in amount, the liberation of this fluid is certainly of therapeutic value. If the ventricle contains simply an abnormal amount of clear serum, this should be evacuated and the cavity of the ventricle either packed lightly with sterile gauze, or lined with sterile rubber tissue as above described. In either case, great care must be taken to prevent infection of the ventricular fluid. We should also remember that a cerebral abscess may rupture into the ventricles, and these cavities must then be opened and drained in order to secure the desired end.

To explore the cerebellum, it is only necessary to make an incision from the upper angle of the ordinary mastoid incision backward to the occipital protuberance. A triangular flap, with base downward, is thus formed. This triangular flap is reflected, the soft tissues being dissected from the underlying bone. In reflecting this triangular flap it is wise not to remove the periosteum, the soft parts being rapidly dissected upward down to the periosteum.

The site of election for an exploratory opening into the cranial cavity for a suspected cerebellar abscess, lies at a point one and one half inches behind the centre of the external auditory meatus, and at a point one quarter of an inch below the horizontal plane passing through the centre of the external auditory canal. For practical purposes, it is necessary for the surgeon to remember that the cranial cavity may be opened at a point an inch and a half behind the centre of the meatus just below the level of the occipital protuberance. After the exposure of the surface of the skull, in the manner already described, the periosteum should be incised at the point of election for perforating the bone. The cerebellar cavity is best entered by means of the chisel or gouge. The bone is very thin in this region, and a few strokes of the chisel are sufficient to break down the bony wall. The opening into the cerebellar fossa is then enlarged by means of the rongeur forceps.

The cerebellar dura should also be exposed in front of the lateral sinus, excepting in those cases where the sinus is so far forward as to preclude this possibility.

After the cerebellar dura has been exposed in these two regions, the surgeon may explore the substance of the cerebellum by incisions either in front or behind the sinus or in both localities, and exploratory punctures made in various directions by means of a grooved director. As soon as the pus is discovered, the introduction of the delicate retractors, already mentioned in speaking of the treatment of cerebral abscess, should be introduced and separated so as to evacuate the purulent collection. In some cases it will be found advisable to institute through and through drainage, that is to open the abscess cavity both in front and behind the sinus, and this procedure was employed successfully in one case seen in consultation by the author.

In cases where the cerebellar abscess is due to infection through the sinus, and where the sinus itself is occluded, the ideal avenue for opening the abscess is through the sinus wall. Owing to the restricted space presented in the cerebellar fossa the region of the lateral sinus would in all cases be the ideal position for exploring the cerebellum for a collection of pus. In cases where the sinus is normal and the surgeon wishes to explore the cerebellum through the sinus, the sinus may be obliterated between the two ligatures passed deeply around the sinus by means of a sharp curved needle. The first ligature should be passed completely around the sinus at a point just below the knee, that is at the point just below where the superior petrosal sinus enters the lateral sinus. The second ligature should be carried about the sinus as far below this as possible. Owing to the irregular shape of the sinus, instead of tying the ligatures completely, the vessel may be very well occluded by tying the ligatures either over a folded strip of gauze or by making use of the device suggested by Major Eagleton.* After the sinus has been obliterated between these two points, the cerebellum can be easily explained through the exsanguinated area.

As soon as the abscess has been entered the operator should introduce the retractors already mentioned in dealing with cerebral abscess, and thoroughly evacuate the cavity. The encephaloscope or the finger may be used at the discretion of the operator. The use of the cigarette drain, packing, and the employment of irrigation depend upon the conditions present.

---

* Verbal communication New York Otological Society, Nov. 26, 1918.

SECTION V.

DISEASES OF THE PERCEPTIVE MECHANISM.

DISEASES OF THE PERCEPTIVE MECHANISM.

THE sound-perceiving apparatus includes the medullary nuclei of the auditory nerve, and the nerve fibres joining these to the cortical areas in the first and second temporal convolutions. Passing from the medullary centres in the opposite direction, it includes the trunk of the auditory nerve and its terminal filaments specialized in the labyrinth for sound perception.

In addition to the perception of sound, the auditory nerve trunk contains a distinct group of fibres which preside over the equilibrium of the body. The terminal filaments of these fibres are distributed to the semicircular canals, while their cortical areas within the cranium are found within the cerebellum. Interference with the perceptive mechanism is consequently attended in most instances by some disturbance of equilibrium. This may be so slight as to entirely escape the notice of the patient unless his attention is particularly drawn to it, or it may be the principal disorder for which he seeks relief. Interference either with equilibrium or with the function of audition, characterized by an impairment in this function or its perversion, may depend upon organic changes in any portion of the mechanism specialized for this particular purpose. It may be also of reflex origin, no structural change having taken place in any portion of the ear, but an affection of some remote organ influencing by reflex action this particular part of the economy.

It follows, therefore, that the history of the individual is of particular importance in connection with diseases of this portion of the auditory apparatus. Some illness in early life, or a slight traumatism, might entirely escape the mind of the patient, as having no bearing upon the condition for which he seeks advice, but may often lead us to a correct interpretation of the cause of a symptom. The physical examination of the ear is really a very small part of the investigation in these cases, and one who confines himself to this special examination alone must invariably fall into error in his attempts to correctly explain the cause of many of the symptoms. Certain phenomena are characteristic of involvement of this portion of the organ of hearing. The hearing power, in cases where the perceptive mechanism is principally involved, is either profoundly affected or but slightly changed, the moderate grades of impairment depending usually upon diseases of the conducting apparatus. Tinnitus is almost always present, and, if carefully investigated, we shall usually find a history of attacks of vertigo. I am of the opinion that sufficient stress is never laid upon the symptoms dependent on labyrinthine involvement in the ordinary cases of diseases of the conducting apparatus. A secondary labyrinthine disturbance may occur as a complication or as a sequel of changes within the middle ear, and yet of itself require no treatment other than that directed to the tympanum. This latter fact does not make it less a labyrinthine affection, the removal of the cause being the rational method for overcoming this disturbance.

With reference to the impairment of hearing, low-pitched sounds are perceived better than those of high pitch, particularly if a preceding disease of the middle ear has led to the involvement of the nervous apparatus. Marked variations in the degree of impairment, dependent upon climatic changes or mental or physical fatigue, are quite as characteristic of a pathological condition located here as they are of middle-ear changes.

Where the power of audition changes with the weather, being worse on damp days and improving as the atmosphere clears, it is usually supposed that the disturbance depends upon a middle-ear affection. If we remember the intimate relation between the venous circulation within the turbinated bodies and the venous return current from the cochlea, we can easily understand how a turgescence of the nasal mucous membrane will cause a venous stasis within the labyrinth. No better proof can be afforded that this is the case than the marked relief to subjective noises often observed when the turbinated tissues are exsanguinated by the use of cocaine.

The duration of the affection and its progress also aid us in determining its site. Primary lesions of the perceptive apparatus either remain quiescent or improve to a certain extent spontaneously as time progresses, excepting, of course, those dependent upon a specific inflammation. Secondary changes within the receptive apparatus, organic in character, are usually due to some chronic affection of the middle ear either of the same or opposite side. When the opposite organ is primarily affected the impairment of function advances rapidly, as a rule, and here the history of previous tympanic disease renders diagnosis clear. The character of the subjective noises is of aid in locating the lesion, in that the particular character of the sound points to the special part of the labyrinth involved. Almost invariably in the secondary labyrinthine changes due to chronic suppurative or nonsuppurative otitis media the subjective noises are high-pitched in character, and assume a deeper quality only after they have persisted for a long period. The complete cessation of tinnitus in these secondary cases probably indicates that the labyrinthine invasion has ceased to progress, and the length of time during which the patient has been free from subjective noises is of aid in determining the probability of restoring the parts to their normal condition by treatment. Vertigo, if severe, points to a sudden and considerable disturbance within the perceptive mechanism, as at the onset of an attack, or to an aggravation of an existing condition. Repeated attacks of giddiness of a mild character would indicate that at these periods the labyrinthine structures or the higher centres were subjected to some unusual stimulation either from the tympanum, from intracranial changes, or of a reflex character from some visceral derangement. The effect of continued stimulation of the nervous mechanism by sonorous vibrations —as when the patient is subjected to the noise of a railway train for a number of hours, or has taxed himself to the utmost in listening to conversation which it has been difficult for him to hear—is of value in diagnosis. Prolonged excitation of any nerve, at length renders it less susceptible to the particular stimulus which has fatigued it. When the nerve structures are in an abnormal condition they become fatigued more easily than when in a state of health; and a patient will often be found to be more deaf after a prolonged railway journey than when he has been comparatively quiet. Physical fatigue may indirectly bring about the same result. It is sometimes said that the paracusis Willisii is characteristic of involvement of the nervous apparatus. This may be true when the patient is subjected to a noise for a short time; but if the stimulation is continued, the nerve becomes fatigued and less responsive to stimuli. The reverse takes place when the nerves preserve their integrity and the conducting mechanism is at fault.

The determination of the special part of the perceptive mechanism involved must remain a matter of doubt in a certain proportion of cases. In general, it may be said that the history of a previous middle-ear affection, of an acute infectious disease, or of a traumatism with a slight impairment of hearing, points to an involvement of the labyrinth. On the other hand, where we have symptoms referable to the ear in cases giving a history of severe injury followed by an involvement of the intracranial structures, as evidenced by other symptoms, or where there are other manifestations of cerebral disturbance at the time of the examination—such as local paralysis, psychic phenomena, etc.—we should suppose that the auditory cortical centres had suffered. An affection of the trunk of the nerve should be suspected when the impairment is to an extent uniform, or affects particularly the perception of those sounds to which the ear is most frequently subjected, since, when all the fibres of the trunk are involved, the fibres which are most constantly used will be most seriously affected. Marked variations in sound perception dependent upon excitement, fatigue, disturbance of the prima viæ, etc., would characterize the aural affection as reflex. Bearing these various points in mind, we should always secure the general history in every case of aural disease, so as to obtain data which will yield the desired information.

CHAPTER XXXIII.

THE EXAMINATION OF THE STATIC LABYRINTH.

The static labyrinth consists of the vestibule and the three semi-circular canals. The semi-circular canals are, as stated in the chapter on anatomy, placed in the three planes of the body, the horizontal semi-circular canals lying in the horizontal plane, the superior semi-circular canals lying in the vertical transverse plane, and the posterior semi-circular canals lying in the anteroposterior vertical plane. It is by virtue of these semi-circular canals that the subject is conscious of his position in space.

Again referring back to the chapter on anatomy, it will be remembered that only one end of each semi-circular canal is ampullated, and that it is in the ampullae of each canal that we have the hair cells which represent the terminal filaments of the vestibular branch of the eighth nerve. In considering the functions of these canals, however, we have simply to deal with the ampullated extremities of the canals, as these extremities only contain the end organs. It must also be remembered that the semi-circular canals on the opposite sides of the body may be considered as a continuous system. In each of the canals the ampullated extremity of the canal is always outward. Each horizontal canal opens by a single ampulla into the vestibule. The superior and posterior semi-circular canals each have an ampullated extremity situated outward, and opening into the vestibule, while the two unampullated extremities of these canals enter the vestibule through the crus communis.

Each canal system can be easily illustrated for purposes of demonstration by the following method:

If the forearms are flexed with the hands clasped behind the head, the plane of the forearms will represent the plane of the horizontal semi-circular canals, and the flexed elbow will represent the ampullated extremities of these canals, the left elbow representing the left ampulla, and the right elbow the right ampulla (see Fig. 158). If the hands are clasped together and placed on top of the head, the arms in this position represent the superior semi-circular system, the left elbow representing the ampulla of the left canal, and the right elbow the ampullated extremity of the right canal (see Fig. 159). If the hands are again clasped, the elbows flexed, and are then placed in the anteroposterior plane of the head, and the hands placed upon the top of the head, and the arms placed in the anteroposterior plane of the body, we have the same representation of the posterior semi-circular canals, that is those canals located in the vertical

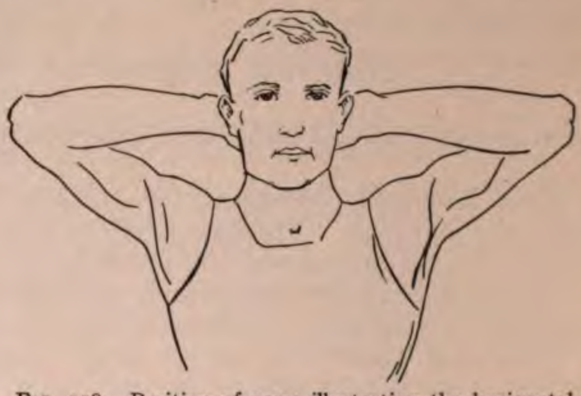


FIG. 158.—Position of arms illustrating the horizontal semi-circular canal system.

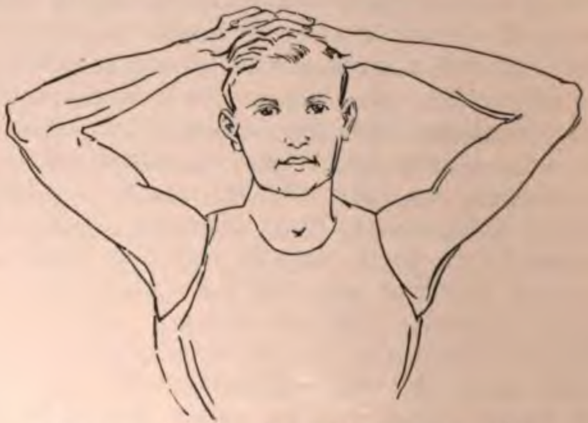


FIG. 159.—Position of arms illustrating superior semi-circular canal system.

anteroposterior plane, the left elbow representing the ampulla of the left vertical canal, and the right elbow representing the ampulla of the right vertical canal.

Another way of representing these canals graphically is by holding the hand of the corresponding side in the horizontal position with the palm upward. The other hand is then flexed at right angles at the metacarpo-phalangeal joint and is placed upon the flattened palm of the other hand, the ulnar aspects of the hands being in apposition (see Fig. 160).

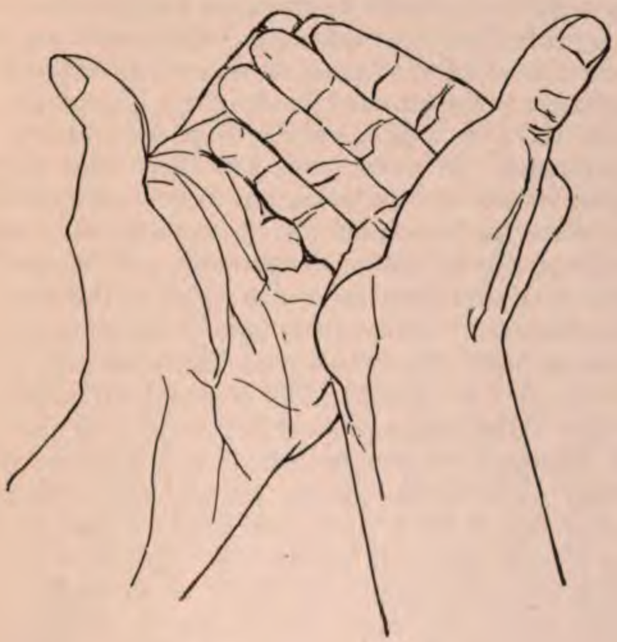


FIG. 160.—Position of hands representing the three semi-circular canals of the left side.

The extended palm, we will say of the left hand, then represents the left horizontal semi-circular canal, and the thecar eminence the ampullated extremity of this canal. Of the flexed right hand superimposed, the flexed fingers represent the left superior semi-circular canal, while the hand itself represents the left posterior semi-circular canal. In order to demonstrate the canals upon the opposite side the position of the hands is simply reversed, the right palm being held horizontally upward, and the left hand being flexed. These two methods enable one to keep more clearly in mind the relative positions of the semi-circular canals. It is important, especially for the beginner, to have some graphic representation of this kind in mind, as otherwise he is apt to become confused.

Referring again to the anatomical portion of this work, there will be found in Plate VI a diagrammatic representation of the distribution of the auditory nerve. Referring to the vestibular branch of this nerve, it will be seen to arise from two nuclei in the medulla, the dorsal nucleus, and Deiters' nucleus. In addition to these there is a third nucleus known as Bechterew's nucleus in the medulla. These three nuclei are the nuclei of origin of the vestibular branch of the auditory nerve. Without going into the subject too deeply, it is important for the clinician to remember that from these various nuclei certain fibers pass to the olivary body of each side and from here to the cerebellum. Fibers also pass from these vestibular nuclei to the region of the third, fourth and sixth nerves. Other fibers pass to the pons and to the tegmentum, while still others pass downward into the spinal cord. Up to the present time it has been impossible to trace any fibers passing from these nuclei to the cerebral cortex. Owing to this wide distribution of fibers from the vestibular nuclei it has seemed rational that stimulation of the vestibular fibers in the semi-circular canals would give rise to certain muscular phenomena dependent upon these fibers of communication. In other words certain definite muscular movements should be elicited by vestibular stimulation. The experiments of Neumann and Barany have put this supposition upon a firm clinical basis. Physiological experiments had before this determined the fact that stimulation of the semi-circular ampullae would give rise to motion of the eyes. These experiments were first made by Hoyges.

From an experiment by Hoyges it was learned that upon stimulation of the horizontal semi-circular canal by a movement of the labyrinthine fluid toward the vestibule, certain definite responses take place in the ocular muscles. If the fluid in the left horizontal semi-circular canal was moved toward the ampullae, as the result of this stimulation there would be a movement of adduction in the left eye, and of abduction in the right eye. This would mean a slow deviation of the eyes to the right. These experiments were carried out in the physiological laboratory, and for a time aroused but little attention as they did not seem to be of much practical value.

It became necessary to discover some means by which the various ampullae could be stimulated in the human subject if use was to be made of this physiological fact. Von Stein and later Neumann conceived the possibility of stimulating the various semi-circular canals by the rotation of the body around a horizontal axis. As the semi-circular canals are filled with cerebro-spinal fluid, it was evident that, if the body were rotated rapidly for a certain number of seconds, we will say in the horizontal plane, gradually the inertia of the fluid in the canals lying in the plane of rotation would be overcome, and the entire fluid contents of the canals would participate in the rotation of the body. If, now, the rotation of the body was suddenly stopped, the fluid in the canals on account of its inertia would still continue to move for a certain period of time. By the movement of this fluid at the time that rotation ceases the hair cells in the ampulla on the side from which the rotation was made would be bent toward the ampulla, while the hair cells upon the opposite side, or the side toward which the rotation was made, would be bent away from the ampulla. In the horizontal semi-circular canal, as already mentioned in speaking of the experiments of Hoyges, it was found that when the hair cells moved toward the ampulla, the stimulation of the combined oculomotor centers, that is the centers of the third, fourth and sixth nerves, caused a slow deviation of the eyes toward the side to which rotation was directed. This deviation of the eye was called nystagmus, and the slow motion was known as the vestibular component of the nystagmus. With the conscious subject, however, this slow motion of the eyes is not observed, or is only observed with difficulty, because as the result of the action of the higher centers, we have to deal with a much more visible and easily demonstrable phenomenon known as the cerebral component of the nystagmus. With the conscious subject, when the basal nuclei tend to deviate the eyes, we will say, to the right, the cerebral function recognizing this deviation, attempts to bring the eyes back to the normal position, and this produces the second phase of the nystagmus, known as the cerebral phase, or the quick component. In speaking of nystagmus it is the quick component with which we always concern ourselves. This quick component is most easily demonstrated if the eyes are turned away from the direction of the nystagmus produced by the stimulation of the vestibular nuclei. To give an example, if, when the head is held so that the horizontal semi-circular canals lie in the horizontal plane, which means that the head is bent about thirty degrees forward, the patient is rotated ten times to the right, at the end of the turning, the fluid in the left semi-circular canal will be moving toward the left ampulla, and in the right semi-circular canal will be moving away from the right ampulla. This will bend the hair cells in the left ampulla toward the ampulla, and will bend the hair cells in the right ampulla away from the ampulla. This means that the left ampulla is stimulated, while the irritability of the right ampulla becomes less than normal. The combined oculomotor centers upon the left side naturally become plus, while those on the right side naturally become minus, and this means a slow deviation of the eyes to the right (see Fig. 161). If, now, the patient opens his eyes and looks to the left, the cerebral component of the nystagmus at once becomes evident, and we have a quick, sharp motion of the eyes to the left. Of course, this quick motion of the eyes to the left will be seen when the patient looks straight ahead, but it becomes more pronounced if he looks in the direction

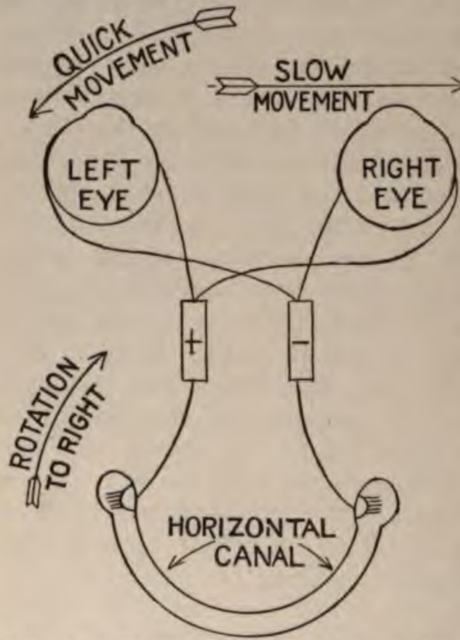


FIG. 161.—Diagram illustrating the resulting nystagmus upon rotation of the patient to the right, the head being held so as to bring the horizontal canals into the plane of rotation.

opposite to that in which he was rotated, that is if by voluntary effort he attempts to overcome the stimulation of the oculo-motor nuclei caused by the rotation. The duration of this nystagmus in the direction opposite to rotation varies in different instances. The average duration is about twenty-five to thirty seconds, or may last five or six seconds more than this, or may fall three or four seconds below this, but between twenty-two and thirty-five seconds can be set down as the normal time of after nystagmus.

This test, as will be seen, enables us to demonstrate the integrity of the combined vestibular apparatus on the two sides as far as the horizontal semi-circular canal is concerned in as far as stimulation of these canals affects the ocular movements. This nystagmus is horizontal in direction, and it must be remembered that all nystagmus following stimulation of any of the semi-circular canals takes place in the plane of rotation, where this stimulation is brought about by rotation.

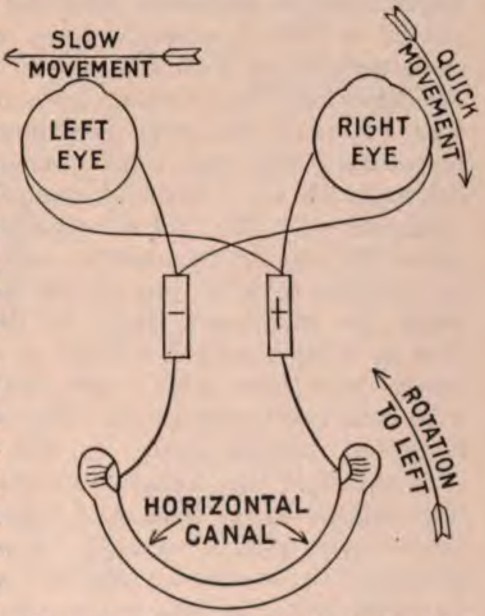


FIG. 162.—Diagram illustrating the resulting nystagmus upon rotation of the patient to the left, the head being held so as to bring the horizontal canals into the plane of rotation.

We have mentioned earlier in this chapter that certain fibers pass from the vestibule to the cerebellum and to the spinal cord. It seems rational, therefore, that stimulation of the semi-circular canals should cause certain phenomena in the movements of the extremities, and this we find to be a fact. In other words, after stimulation of the semi-circular canals by rotation or otherwise, we have certain definite variations in voluntary body movements as the result of this stimulation. In other words we have over pointing. If in the normal subject the eyes are closed, and the subject brings his index finger, the other fingers being flexed in the palm, in contact with the finger of the examiner, and is then told to raise his arm quickly above his head and bring his finger down in the vertical plane so as to touch the examiner's finger, we find that he is able to do this without any difficulty. In other words, under normal conditions there is no over pointing. This lack of deviation also occurs in pointing in the horizontal plane. The hand can be carried out to the side, the arm carried at right angles to the body, and then swept inward, always finding the examiner's finger. In the same way with the lower extremities, if the patient is told to raise the lower extremity and touch the examiner's finger with the toe, he is able to do this under normal conditions without any difficulty. Now suppose that we make this same experiment after rotation in the horizontal plane, and I am confining myself at present to dealing with the horizontal semi-circular canal to prevent confusion. At the end of rotation it will be found that when the patient attempts to touch the examiner's finger, he is unable to do so, but will persistently over point or past point the examiner's finger in the direction of rotation, that is, if he has been rotated to the right, he will persistently over point to the right with both hands, and also with both lower extremities. Also if allowed to step quickly from the rotating chair, he will fall to the right. The explanation of this seems to be that, when the patient has been rotated to the right, and this rotation suddenly ceases, subjectively objects seem to be moving to the left. He attempts to overcome this by moving to the opposite direction, hence he falls to the right, and over points to the right.

I have tried to make clear here that by this process of rotation we have a means of determining the integrity of the semi-circular canals, that is of the end organ of the static portion of the auditory nerve, and also the integrity of certain nerve fibers, namely of the entire vestibular branch of the eighth nerve, and also those fibers of communication running from the nuclei of the eighth nerve to the oculo-motor nuclei (so called for convenience), and also the integrity of fibers running down to the spinal cord. In other words this method of rotation enables us to determine not only lesions of the end organ of the vestibular nerve, but also lesions of the nerve trunk and of communicating fibers within the brain.

In order to carry out these experiments so as to make use of them clinically, it is necessary to have a rotating chair, one with a firm base so that after rotation the patient will not topple the chair over, and moreover, one in which the rotation can be stopped suddenly without overturning the chair. Some observers prefer a chair which can be fitted with an automatic brake. I have never found this elaborate device necessary. In performing the rotation it is well for the observer to stand behind the patient as he is less apt to become confused as to the direction of the rotation if the patient and himself are looking in the same direction. Standing behind the patient, the chair is turned ten times in ten seconds, or ten times in twenty seconds, the exact length of time not being particularly material. The rotation of the chair is then suddenly stopped, and the observations made.

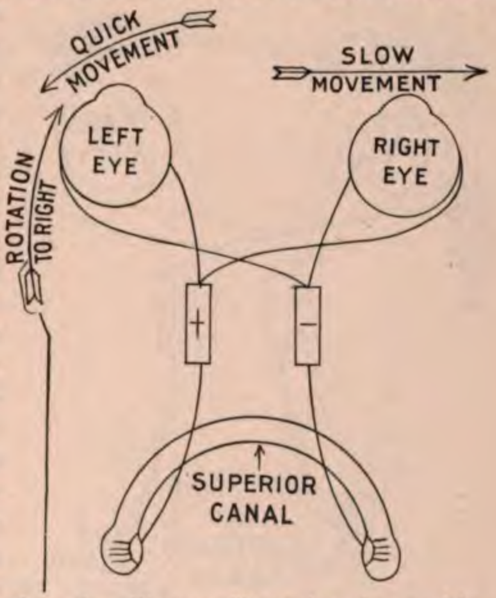


FIG. 163.—Diagram illustrating the resulting nystagmus upon rotation of the patient to the right, the head being inclined 60 degrees forward so as to bring the superior semi-circular canals into the plane of rotation.

So far we have dealt only with the horizontal semi-circular canal. It is naturally necessary, if we are to test the other semicircular canals by rotation, to bring these canals into the plane of rotation in order to make the test. The graphic representations of the positions of the various semi-circular canals are depicted in figures 158 and 159. It will be seen that, in order to stimulate the superior semi-circular canal, the head must be bent forward at an angle of 90 degrees. This will bring the superior semi-circular canal in the horizontal plane. If, now, the patient is rotated to the right, at the end of the turning we will have a quick nystagmus to the left (see Fig. 163), we will have falling to the right, and over pointing to the right. This may at first seem confusing because in this instance the direction of the fluid in the semi-circular canal will be away from the left ampulla, and toward the right ampulla. It has simply been demonstrated by physiological experiments that in the case of the superior semi-circular canals the motion of the fluid away from the ampulla causes the stimulation of the corresponding oculomotor center, while the motion toward the ampulla renders this center less irritable. This, of course, is directly opposed to what occurs in the horizontal semi-circular canals.

It naturally goes without saying that the superior semi-circular canal can also be stimulated by bending the head backward 90 degrees, thus bringing the superior semi-circular canals in the horizontal plane. This position, however, is extremely uncomfortable to the patient. As we will see by figure 164, if the head is bent backward instead of forward, the direction of the nystagmus, as well as of the overpointing, will be reversed, as under these conditions the fluid, if the patient is turned to the right, will be moving toward the left ampulla, and away from the right ampulla.

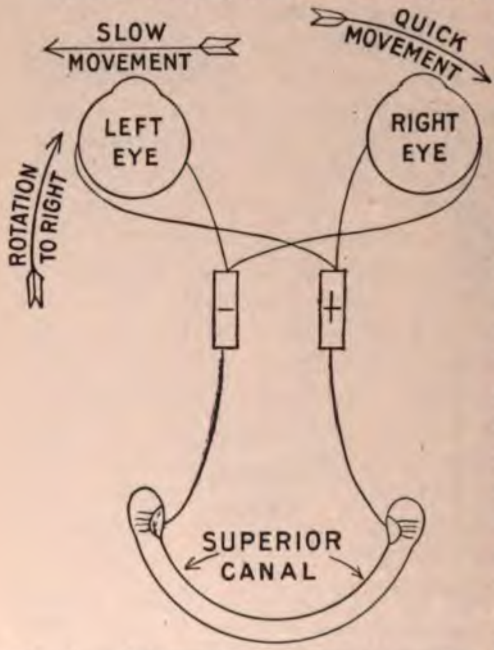


FIG. 164.—Diagram illustrating the resulting nystagmus upon rotation of the patient to the right, the head being bent backward so as to bring the superior semi-circular canals into the plane of rotation.

It will be seen from what has gone before that the preservation of equilibrium and the lack of any rhythmic movement of the eyes depend upon the absolute balance of the vestibular apparatus upon each side.

Under certain pathological conditions the static labyrinth of one side may be destroyed completely by disease, or the vestibular portion of the nerve may be destroyed, or the basal nuclei prevented from performing their functions as the result of some pathological process. Under any of these conditions the patient will suffer from severe vertigo and spontaneous nystagmus with a quick movement to the healthy side, over pointing to the diseased side, and falling to the diseased side. These symptoms persist for varying periods of time, but naturally they do not last forever. For a diagrammatic representation of the mechanism of these manifestations see figure 165. In time the healthy labyrinth takes up the function of the one destroyed by disease. In other words compensation takes place here as it does in every part of the body. The patients then lose their vertigo, nystagmus, over pointing, and instability.

It must be remembered in considering the investigations of the static apparatus by turning that this turning affects both labyrinths at the same time, that is when the fluid passes from one ampulla, stimulating this, it exerts an opposite effect on the ampulla of the other side, rendering this less irritable and magnifying twofold the stimulation upon the opposite side. When we come to test a patient with a dead labyrinth by means of turning, after all subjective and objective symptoms with reference to the static labyrinth have disappeared, we find that there is very little difference in the duration of the after nystagmus where the patient is rotated either toward the diseased side or away from the diseased side. The absolute duration of the nystagmus is short, but the time of the after nystagmus does not vary beyond the physiological variation. The rotation test, however, would leave us comparatively in the dark as the

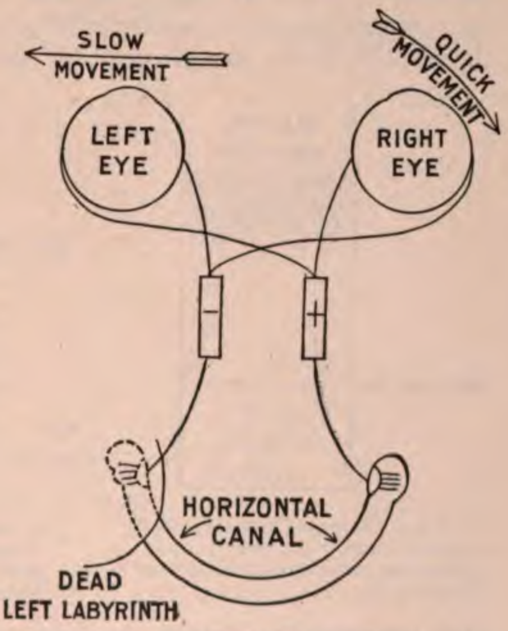


FIG. 165.—Diagram illustrating spontaneous nystagmus when the left labyrinth is dead.

presence of a dead labyrinth after compensation had taken place. We must, therefore, have some means of testing each static labyrinth separately, and this method was given us by Barany, making use of the caloric test. We know that if we have a vessel full of fluid, and then apply heat to the walls of the vessel, a current will be established in the fluid, the warmer particles tending to rise to the surface (see Fig. 166). Similarly, if we cool the side of the vessel, a downward current will be established in the fluid, the colder particles of the fluid tending to sink (Fig. 167). This gives us a means of testing each labyrinth separately. If, with the patient in the upright position, we syringe one ear with a fluid considerably higher in temperature than the body temperature, we have an upward current established in the superior semi-circular canal, this current moving away from the ampulla, stimulating the oculo-motor centers of the same side. This gives us a slow motion of the eyes away from the ear syringed, and a quick component of the rotatory nystagmus in the direction of the side tested (see Fig. 168). The patient similarly will over point to the opposite side, that is in the direction of the slow movement of the eyes, and will also tend to fall to that side. Similarly, if the ear is syringed with water at a temperature lower than that of the body, a rotatory nystagmus will be produced. In this case the motion of the fluid current is toward the ampulla, and in the superior semi-circular canal

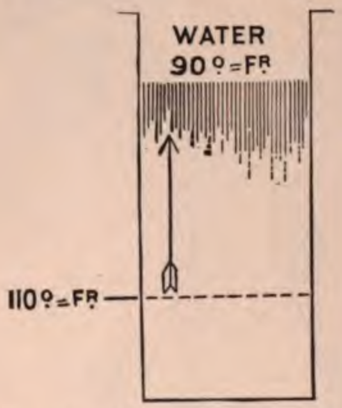


Fig. 166.—Diagram illustrating the upward current produced in fluid when the outside of the vessel is heated.

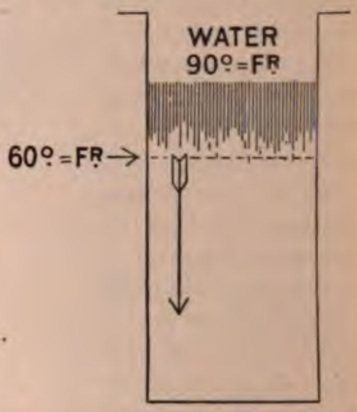


Fig. 167.—Diagram illustrating the downward current produced in fluid when the outside of the vessel is cooled.

we remember that when this occurs, the canal is rendered less irritable. The opposite center then becomes plus with a slow motion of the eyes toward the side syringed. The quick component of the nystagmus will be rotatory in character and toward the opposite side (Fig. 169). The over pointing and falling will occur toward the side syringed.

The irritability of the labyrinth to caloric stimulation varies considerably in different cases. Naturally the caloric reaction will be greater, and will be more pronounced the more the temperature of the water varies from the normal temperature of the body. The degree of irritability of the labyrinth can be roughly determined by noting the difference in this temperature variation, that is whether very warm or very cold water has to be used to produce the reaction, and also the length of time that the ear has to be irrigated before the reaction appears, as well as the length of time that the reaction persists. Under normal conditions one syringe full of water cooled with ice will bring on a nystagmus almost immediately, and this nystagmus will persist for from one to two minutes or sometimes longer. As cold water is much better borne by the ear than hot water, the reaction produced by cold is usually more pronounced than that produced by heat.

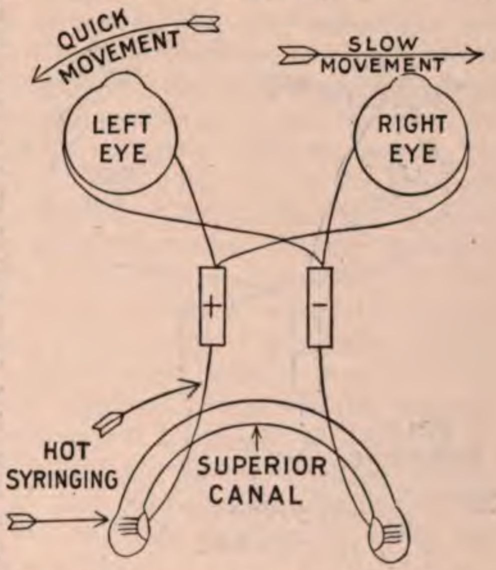


FIG. 168.—Diagram illustrating the nystagmus produced when the left ear is syringed with hot water.

We find certain cases, particularly those suffering from some lesion of the central nervous system, in which spontaneous nystagmus in one or both directions occurs. If, for instance, we have a spontaneous nystagmus toward the right, this would naturally mean a dead labyrinth on the left side. How are we to determine whether the function of this labyrinth is absolutely destroyed or not?

Manifestly syringing the ear with cold water will not aid us for this would produce a nystagmus to the right, and it is hard to tell in any case whether the nystagmus is increased by the test. If, however, in such a case we syringe the left ear with water as hot as it can be borne, if the labyrinth still remains active, the spontaneous nystagmus to the right will be either ablated or considerably diminished, or if the activity of the labyrinth is normal, there will be found produced a nystagmus to the left side. This enables us to determine the absolute or partial destruction of any labyrinth in any given instance. In certain cases of intracranial lesion we may have spontaneous nystagmus in each direction, and here the same test will apply, that is syringing one ear with cold water will, if the labyrinth is irritable, ablate the nystagmus toward the side syringed, and increase the nystagmus to the opposite side.

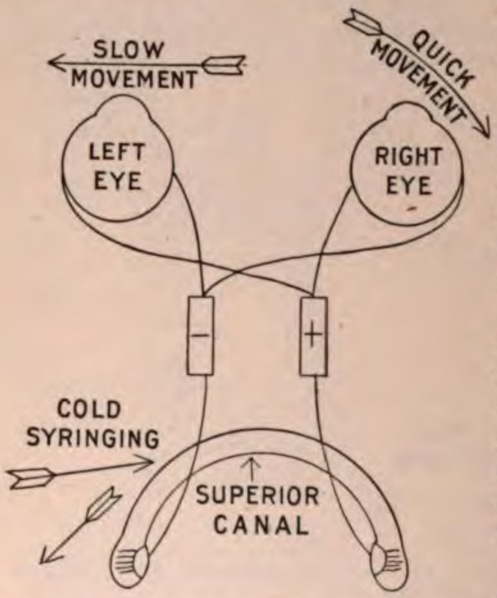


FIG. 169.—Diagram illustrating the resulting nystagmus when the left ear is syringed with cold water.

In certain cases it is necessary to test the relative irritability of each labyrinth. This can be done by a double caloric test, that is making use of an irrigator provided with a double discharge tube, and allowing water to flow into both external auditory canals at the same time. This will clearly show which labyrinth is the more irritable. Naturally in normal cases this experiment would be followed by no nystagmus, but, if one labyrinth is more irritable than the other, the nystagmus will occur away from the side of the more irritable labyrinth, if cold water is used, or toward the side of the more irritable labyrinth, if hot water is used.

Another reaction which is also of value, particularly in cases of lesions of the auditory nerve trunk, is the galvanic reaction. To apply this test we make use of the galvanic current, employing about forty volts of current, and applying a large, flat electrode to some neutral point such as the palm of the hand, while the other electrode is placed over the ear tested. It will be found on passing the current that a rotatory nystagmus will occur toward the side to which the cathode is applied, this nystagmus being more pronounced if the patient is directed to look upward and outward, toward the side tested. It requires about eight or ten milliamperes of current in normal cases, and even this may sometimes not produce a nystagmus if the labyrinth and auditory nerve trunk are normal. If the labyrinth, or particularly if the nerve trunk is abnormally irritable, a current of even two or three milliamperes will produce a nystagmus. If the anode is applied to one side, the nystagmus will occur in the opposite direction, that is when the patient looks upward and outward away from the ear to which the electrode is applied. The relative irritability of each labyrinth or auditory nerve trunk is tested by placing one electrode over each ear, and then gradually passing the current. Under normal conditions no reaction will take place, but where one labyrinth is more irritable than the other, the cathodal reaction will be toward the side of the more irritable labyrinth, and the anodal reaction will be away from the side of the more irritable labyrinth, the patient being directed to look in the direction in which the rapid movement would occur.

From what has been said regarding the tests of the eighth nerve and its end organ, it goes without saying that any interference with the eighth nerve itself, or its central nuclei, or the fibers of communication between these nuclei and the cerebral centers, may frequently be diagnosed by the application of the tests already laid down. Certain definite signs appear on careful physical examination of the eighth nerve when any pathological process involves the structures before mentioned. By these tests, in conjunction with certain phenomena referable to the eighth nerve and its fibers of communication, we are able to diagnosticate with a fair degree of certainty tumors of the cerebello-pontine angle involving the eighth nerve, tumors of the eighth nerve in the porus acusticus internus, and also the destruction of certain portions of the cerebellum to which fibers from the basal nuclei of the eighth nerve pass, and also certain conditions in the mid-brain when the parts involved contain fibers passing from the basal nuclei to the nuclei of the ocular muscles.

For instance, if we have a tumor of the acoustic nerve or of the base at the cerebello-pontine angle with pressure on the nerve, we are apt to have impairment of hearing, or absolute deafness on this side, vertigo with a tendency to fall toward the side of the lesion, over pointing toward the affected side, and spontaneous nystagmus. If this nystagmus is slow, that is if the cerebellar component of the nystagmus is pronounced enough to overcome the cerebral, then there will be slow nystagmus to the affected side. Quite as frequently, however, where the lesion is extensive, we find that the slow component of the nystagmus is not demonstrable, and we then have a rapid nystagmus toward the healthy side. In cases of tumor of the porus acusticus the x-ray plates may show a dilatation of the internal auditory meatus due to the pressure of the growth.* Naturally, the caloric test in such cases will either be absolutely negative, or there may be a slight caloric irritability of the labyrinth, but this will be impaired. The rotation tests may show no change except the shortened reaction for the diseased side, provided this labyrinth is entirely dead, or provided the function of the nerve is completely ablated.

The galvanic test is apt to show increased irritability of the nerve. The double caloric test and the double galvanic test are of particular value in cases of this kind. Similarly when the fibers of communication are interfered with, we may, for instance, have a normal nystagmus following a caloric reaction, but an absence of over pointing. This would indicate that, while the fibers passing upward to the ocular muscles are intact, those fibers passing to the cerebellum and downward to the anterior horns of the spinal cord are interfered with. In certain cases the converse is true, that is the caloric and rotation tests may produce a normal over pointing, but not a normal nystagmus, showing that the fibers passing upward to the ocular muscles are involved.

There also seems to be evidence to prove that the superior semi-circular canals and horizontal semi-circular canals pass by different paths. It is, therefore, important in cases of suspected intracranial disease to test the reactions not only of the horizontal semi-circular canal, but also the superior semi-circular canal. The fibers from the horizontal semicircular canals seem to pass to Deiters' nucleus, thence to the cerebellum by way of the internal portion of the inferior cerebellar peduncle, through to the cerebellar nuclei, globus fastigii and emboliformis, and then to the cortex of both sides. The fibers of the superior canals probably go to the posterior longitudinal bundle, and enter the cerebellum through the middle peduncle. It can be seen, therefore,

---

* Cushing—"Tumors of the Acoustic Nerve."

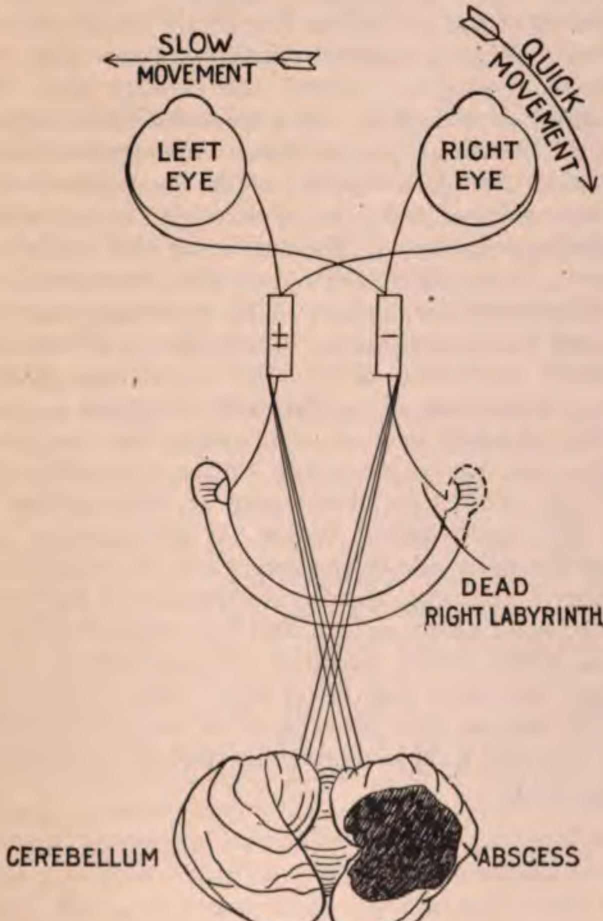


FIG. 170.—Diagram illustrating the cause of nystagmus toward the affected side when the right labyrinth is dead and there is a cerebellar abscess upon this side.

that, if this hypothesis is correct, it is valuable to test the integrity not only of the horizontal canals, but also of the superior canals, and that by doing this we may be still further able to localize the intracranial lesion.

It is interesting also to note that in cases of cerebellar abscess where infection has taken place through the labyrinth the character of the nystagmus frequently enables us to make a diagnosis. With a dead labyrinth, we know that we have spontaneous nystagmus toward the healthy side. In any case of aural suppuration where the caloric test shows that one labyrinth is dead, a spontaneous nystagmus toward the diseased side, that is a reversal of the nystagmus which we would ordinarily expect, points strongly to an abscess in the cerebellar substance. The reason for this is explained in figure 170. In this figure we assume that the right labyrinth has been destroyed by disease. This would give us a nystagmus toward the opposite side. Gradually, however, owing to the crossed cerebellar fibers, the nystagmus disappears, and the disturbance of equilibrium disappears. In other words the opposite centers compensate for the destroyed labyrinth, and the oculo-motor center upon the left side becomes ±. This over developing of the negative phase of the left oculo-motor center is undoubtedly brought about by the right side of the cerebellum through the decussating fibers. If, now, there is destruction of the cerebellar substance, this balance is lost, and the negative phase of the left oculo-motor center becomes predominant as this is the one which has been last developed. This being the case, we would have a slow movement of the eyes toward the healthy side, and a rapid nystagmus toward the affected side. (See Fig. 170.)

CHAPTER XXXIV.

ANÆMIA OF THE LABYRINTH.

Ætiology.—The condition may depend upon profuse general hæmorrhage, either from traumatism, from the rupture of an aneurism, from uterine hæmorrhage at childbirth, or may be the result of simple or pernicious anæmia. The changes which take place are due to the impoverished quality of the blood with which the tissues are supplied, the lack of nutrition perverting their function and rendering them less capable of carrying out the purposes for which they were designed.

Symptomatology.—When the labyrinthine structures suffer in this manner we find the power of audition impaired, particularly for sharp sounds and musical notes of a high pitch. The involvement of the auditory function is similar in character to the disturbance which is noticed in every part of the body. When nutrition is imperfect no organ performs its work properly. When the labyrinth suffers from malnutrition the patient seems listless and inattentive, and it requires a certain effort upon his part to hear what is said. When engaged in dialogue the hearing may not seem to be much affected, but when several are speaking at once he is unable to follow accurately the course of the conversation. Subjective noises are distressing, and are usually worse upon lying down, depending upon the adynamic condition of the circulatory system. The character of the subjective sounds is usually dull and low-pitched, synchronous with cardiac pulsations, and is apparently identical with the venous bruit heard over the great vessels of the neck in many cases of anæmia. Attacks of vertigo seldom occur spontaneously, but result from apparently slight causes, a sudden fright being sufficient many times to induce an attack of syncope, while the same condition may follow an insignificant degree of pain or some slight visceral disturbance. The facies of the patient is somewhat characteristic, in that it appears dull, abstracted, and inattentive. The other symptoms presented are those common to simple anæmia, and bear no relation to the portion of the body now under discussion.

Diagnosis.—The pallor of the skin found after an acute hæmorrhage, or the peculiar ashy-gray color met with in cases of simple or pernicious anæmia, should always attract attention. The variation in color from the normal standard is frequently better observed in the mucous membranes than in the cutaneous surface of the body. These may appear blanched, although the face is not sufficiently pallid to excite attention.

A. *Physical Examination.*—In cases of simple anæmia, examination with the otoscope reveals nothing characteristic of the affection, and, unless the middle ear is involved, the inspection is entirely negative.

B. *Functional Examination.*—The lower tone limit is normal; the upper tone limit may be normal or reduced; bone conduction is almost always reduced to a marked degree. The perception of whispered or spoken words is somewhat reduced, although it may be nearly normal. It will be noticed that the words are repeated in an uncertain manner and slowly, as though it took the patient some time to comprehend exactly what had been said. This is due to inco-ordination in the receptive mechanism, the different portions failing to act in harmony. Perception for high sounds, as the tick of the watch or the click of the acoumeter, is usually more reduced relatively than for vocal sounds.

The essential points upon which the diagnosis is made are:

First, the absence of any middle-ear lesion.

Second, preservation of the normal tone limits (or reduction of upper limit).

Third, marked impairment of bone conduction.

Fourth, the anæmic appearance of the patient.

Prognosis.—In acute cases depending upon hæmorrhage, or in cases of simple anæmia, the prognosis is always favorable. In pernicious anæmia, extravasations within the nerve tissues may have taken place, producing permanent structural changes.

Treatment.—Certain drugs, such as iron in full doses, or arsenic, either in the form of arsenious acid, Fowler's solution or Pierson's solution, etc., should be administered for the purpose of improving the quality of the blood. The exhibition of cardiac stimulants is also advisable to relieve the venous congestion within the labyrinth. Strychnine fulfills this end, and at the same time exerts a beneficial effect upon the nervous tissues themselves. This may be given simultaneously with ferruginous preparations, and should be administered in full doses. The diet should be liberal, and of such character as to improve the quality of the blood. The exhibition of alcohol in any quantity is not advisable, excepting in acute cases, or possibly to the extent of a little red wine at dinner. Quinine is particularly contraindicated in this condition. It is true, that many cases improve temporarily when this drug is administered; but it is equally true that they almost invariably suffer from a relapse, and that the symptoms are more marked than those which characterized the primary attack. The temporary engorgement which this drug induces in the labyrinthine vessels often leads to permanent changes of a hæmorrhagic nature. The temporary relief gained is due to the increased vascularity which the drug causes, and not to correction of the condition upon which the symptoms depend.

CHAPTER XXXV.

HYPERÆMIA OF THE LABYRINTH.

Ætiology.—An increased quantity of blood within the labyrinth may depend either upon a venous stasis from mechanical obstruction to the return current, or upon an increased quantity of arterial blood conveyed to the part. The condition is prone to occur in individuals of a full habit, and particularly in those who are the victims of a gouty or rheumatic diathesis. Those whose vocation in life demands considerable physical activity or exposure to inclement weather are frequently victims of this condition. Sudden physical exertion is productive of these circulatory changes, especially in athletes. Overindulgence in alcohol, by increasing the force of cardiac systole, leads to distention of the labyrinthine vessels. Rigidity in the arterial system, by diminishing the elasticity of the vessels, increases relatively the pressure within the arteries. Sudden diminution in atmospheric pressure, as when one ascends to a great height, subjects the efferent vessels to the full force of the cardiac systole, and hence augments the blood passing through them. The prolonged action of any one sound also produces hyperæmia, either mechanically or from over-stimulation, as is observed in telephone operatives, boiler-makers, etc. Condensation of the air in the meatus, from a blow on the ear or from an explosion, forces the stapes suddenly inward to an abnormal distance, and may cause hyperæmia of the labyrinth. It is probable that cases of mild labyrinthine concussion are of this nature.

Among those causes which lead to a venous stasis we may enumerate mechanical obstruction to the great vessels of the neck, such as pressure from a tumor or the sudden lowering of the head, the venous flow being then retarded by the force of gravitation. A severe attack of coughing, by increasing the pressure within the thorax, temporarily obstructs the passage of the blood into the right auricle and dams back the entire venous circulation. Efforts at sneezing, blowing the nose, etc., exert the same influence.

Pathology.—The overdistention of the blood vessels produces but few changes so long as their walls are in a state of perfect health; when continued for a long time, localized dilatation takes place, causing an irregularity in the blood supply. Where the pressure changes are sudden, or where the walls of the vessels are diseased, they may rupture and produce apoplectic changes. A venous hyperæmia is more prone to become permanent on account of the tenuity of the vessel walls. The labyrinthine veins are to a great extent inclosed in bony channels, for the purpose of avoiding this condition. Their exposed portions, however, suffer when an obstruction to the venous circulation persists for a considerable period; the vessels become tortuous and dilated, and there is a transudation of serum into the labyrinthine cavity. Both the venous dilatation and the serous transudation increase labyrinthine pressure. The ultimate changes which take place in labyrinthine apoplexy do not differ from those occurring in a similar condition in other parts of the body. The effused blood may be absorbed, or the affected area may undergo disintegration.

Symptomatology.—Such an augmentation in labyrinthine blood supply is characterized by a feeling of fullness and distention in the head, slight giddiness or even vertigo, and the presence of subjective noises, usually of high-pitched character. The impairment in hearing is slight, unless the vessel walls suffer; then it may be profound or even absolute, the accompanying giddiness being usually severe, and the tinnitus at first almost unbearable. Occurring as a chronic condition in a patient of full habit, we find these symptoms produced by any slight exciting cause, such as fright, rage, sudden exertion, indigestion, too free indulgence in stimulants, etc.

Diagnosis.—*Physical examination* yields no information beyond showing an increased vascularity in the drum membrane and the deeper parts of the canal, causing the vessels to be more distinctly visible than normal. Where the membrana tympani is thin, a similar condition is often observed in the mucous membrane of the promontory.

Functional Examination.—The lower tone limit is exceedingly well preserved; the upper tone limit is usually reduced; bone conduction is diminished, and the power of audition for vocal sounds but slightly impaired. For sharp sounds, such as those of the acoumeter or watch, a condition of hyperacusis may be present, and very sharp sounds are often painful; or the auditory impression may persist for some time after the source of sound has been removed. The diagnosis in chronic cases will be rendered more easy if attention is directed to the increased vascularity of the integument of the face and the prominence of the smaller vessels beneath the skin, which is a fair index of the condition of the circulatory system within the labyrinth. The history of severe physical exertion or of a gouty or rheumatic diathesis also materially aid us in arriving at a correct opinion.

Prognosis.—Where but slight impairment of hearing is present, we may hope, in recent cases, to effect an absorption of the effused serum and a return of the parts to a condition of integrity. Where the condition is of long standing, the outlook is more unfavorable, and the same is true where the changes are of hæmorrhagic nature, if the extravasation is of considerable size. In chronic cases it is seldom possible to remove the condition entirely, although much relief may be secured by carefully regulating the habits of life.

Treatment.—In severe cases local depletion is a most important measure to be adopted. Considerable blood should be abstracted from the mastoid region by means of the wet cup. General bloodletting is permissible when the attack is of unusual severity. Free catharsis should be effected by the administration of saline purgatives, and free diuresis should also be obtained. In acute cases it is well to protect the ear from the action of sound by occluding the meatus with cotton. The application of counterirritants to the mastoid in the form of blisters is advocated by some, but is of more value where the condition has continued for some time than immediately after an exacerbation. The use of counterirritation for a long period by means of the tincture of iodine applied to the mastoid region is of some value in the older cases, since the effusion of serum within the labyrinthine chamber implies an increase in pressure. The use of pilocarpine is of benefit, and we should always resort to it if prompt relief does not follow the abstraction of blood. In administering this drug, it is convenient to employ a four-per-cent solution, as in this way the dose can be gradually increased according to indications. The initial dose for an adult is from one sixth to one eighth of a grain twice or three times daily. It is not necessary to confine the patients to the house to the extent of interfering with their daily vocations in carrying out the treatment. It is only necessary that for about two hours after each dose the patient should guard against draughts. This is secured if one dose of the drug is taken immediately upon rising in the morning, when the effect will have passed sufficiently before the patient is obliged to go out to his daily work, while the second may be taken upon retiring. The quantity administered should be just sufficient to increase the salivary or cutaneous secretions slightly, but a profound effect is undesirable. The patient should be directed to increase the dose, so that the physiological action is noticed after each ingestion, as otherwise tolerance is soon established and the full benefit to be derived is not obtained. It is also of great value in instances which come under treatment only after a considerable interval has elapsed since an acute attack, the reduction in pressure frequently being followed by relief. This is probably due to the absorption of the effusion. Iodide of potassium internally, in doses of ten grains three or four times daily, may be given for the same purpose, but is usually less efficacious. Next to the treatment of an acute attack, the most important measures are those of a prophylactic nature. Severe and sudden physical exertion should be enjoined. Alcohol should be interdicted, and the diet should be so regulated as to diminish the general plethora. The influence of a gouty or rheumatic taint should never be forgotten, and the prolonged use of some alkaline waters, preferably those containing lithium, is of great value. Attention to these matters not only tends to relieve the chronic congestion, but also renders the patient less liable to an apoplectiform lesion.

CHAPTER XXXVI.

LABYRINTHINE HÆMORRHAGE.

Ætiology.—The cause of a rupture of the walls of the labyrinthine vessels, with an extravasation of their contents into the delicate structures which the cavity contains, may be due to external violence, such as a blow upon the head or a fall from a height, or the sudden action of a loud sound, such as an explosion. It may be caused by manipulative procedures directed toward the relief of some middle-ear condition, as a forcible inflation by means of the catheter or Politzer bag, or severe efforts at coughing or sneezing. Mobilization or removal of the stapes may also produce the condition under discussion.

Various conditions of the blood itself—such as that found in the hæmorrhagic diathesis, in pernicious anæmia, and in leucæmia, or fragility of the walls of the blood vessels met with in patients of advanced years, especially those who are victims of a gouty diathesis—may determine the same result. The same accident may take place from sudden venous congestion of the head, as produced when one remains with the head bent forward for a considerable time, or when the venous blood is prevented from entering the right auricle by holding the breath, as in swimming under water or in diving. Necessarily the condition may be met with as a complicating lesion of cerebral hyperæmia.

Pathology.—The effusion of blood into the tissues produces the same changes here as a similar lesion in other parts of the body. Where the hæmorrhage is considerable, complete disorganization of the parts may take place from pressure, and a return to the normal condition becomes impossible even if the effused blood is subsequently absorbed. In other cases the traumatism is not so great, and the structures pressed upon simply suffer from a mechanical interference with the performance of their function without undergoing degeneration; this is always produced by increased labyrinthine pressure, when the equilibrium is restored only after a considerable period. The clot itself may remain and become organized, or may be completely absorbed or undergo fibrous or calcareous degeneration. According to the amount of original damage, the function of the part is either entirely destroyed or partially or completely restored.

Symptomatology.—When a labyrinthine apoplexy occurs, the patient is usually seized with giddiness so severe as to cause him to fall unless he obtains some artificial support; at the same time there is intense nausea, severe tinnitus, and a very high degree of impairment of hearing, or absolute deafness. Unconsciousness may occur if the attack is severe. When it follows chronic labyrinthine hyperæmia, certain premonitory signs often manifest themselves, such as a feeling of fullness and distention in the head, a throbbing within the ears, the cardiac impulses being not only heard, but apparently felt deep in the head. The unsteadiness of gait and impairment of hearing usually disappear after a few days or weeks, the former completely, and the latter to a marked degree, although the hearing does not become normal. The subjective noises persist, and may even increase in severity. Occasionally a condition of hyperæsthesia of the auditory nerve follows, certain sounds being painful, although the general auditory power is greatly impaired. An attack of this kind renders it probable that subsequent attacks may occur, especially when it is due to a pathological condition of the walls of the blood vessels.

Diagnosis.—The suddenness of the attack, the severity of the vertigo and of the tinnitus, the extreme nausea, and the sudden and marked impairment in hearing form a series of symptoms which are fairly characteristic. A physical examination reveals no departure from the normal standard.

Functional examination, in addition to the impairment of hearing, both for spoken words and sharp sounds, will show an impairment or absence of sound perception through the solid media of the skull. The limits of audition may be variously affected, according to the particular site of the lesion. Generally the lower portion of the labyrinth is involved, in which case the lower tone limit remains normal, while the upper tone limit is lowered to a very marked degree. This is not absolute, for if the hæmorrhage occurs in the upper part of the cochlea high notes may be the only ones heard, while the low notes are not perceived at all.

Prognosis.—When the hæmorrhage involves but a very small area, spontaneous recovery may take place. When the lesion is extensive it is probable that the hearing will remain to a degree impaired whether the case be left to itself or subjected to medication. Improvement may be hoped for in the more severe cases rather than in those where the extravasation is moderate. The prognosis as to the disappearance of subjective noises is less favorable, and complete relief should never be promised. The disturbance of the equilibrium usually disappears completely.

Treatment.—When seen immediately after the attack, local depletion and even general bloodletting are the first measures to be instituted. A wet cup to the mastoid exerts more influence upon the circulation within the labyrinth than when applied in any other location. Free purgation should then be effected, absolute rest in bed enjoined, and the patient should be protected, as far as possible, from loud noises, and forbidden to do any manual work. At a later period the administration of pilocarpine, beginning with a dose of one sixth of a grain three times daily and increasing rapidly until the physiological effect is obtained, often causes rapid improvement by reducing labyrinthine pressure. The general condition should be attended to in the same manner as directed under labyrinthine hyperæmia. Iodide of potassium, continued for six or eight weeks, seems to favor the absorption of the clot. Counter-irritation over the mastoid process by means of iodine or vesicants is a measure to be employed if convalescence is delayed. Great care should be taken to warn the patient of the danger of a similar attack at some future time.

CHAPTER XXXVII.

LABYRINTHINE EMBOLISM AND THROMBOSIS.

Ætiology.—The lodgment in one of the smaller vessels of the internal ear of an infectious embolus which may have been thrown into the circulation as the result of a pathological change in some distant organ, or the development of infectious thrombi within the venous channels, are both conditions met with in rare instances. Embolism is specially rare, although it has occurred in cases of osteomyelitis, and has been produced artificially in the lower animals by the injection of some of the low vegetable organisms into the blood. A thrombosis occurs more frequently as the result of a severe suppurative process within the middle ear, such as is found in scarlatina, diphtheria, etc. Here the blood supply of the external labyrinthine wall is greatly interfered with, and infection takes place by contiguity of structure through the osseous partition. This form of occlusion of the venous channels constitutes the labyrinthine lesion in many cases which suffer from severe purulent otitis during one of the exanthemata.

Pathology.—The occlusion of an arterial twig produces at first an anæmia of the area which it supplies; this may go on to disintegration if the blood supply is not re-established, but if the collateral circulation is free this may not occur. Thrombosis of a venous trunk is of less importance except where it is due to an acute infectious process, when the minute septic foci may break down and produce severe inflammation of the surrounding parts.

Symptomatology.—The symptoms, in general, resemble those of labyrinthine hæmorrhage, except that they are less severe; nausea is rare; vertigo may be scarcely noticeable, and the hearing power but slightly impaired. The sudden development of tinnitus in these cases is probably the most constant symptom. It is probable that in many instances where tinnitus alone is complained of, the hearing power being normal, according to the most careful tests, a small artery or vein within the labyrinth has become occluded, causing sufficient structural change to produce this symptom without otherwise impairing the function of the organ to a noticeable extent. From the intimate relation between the venous current within the turbinated bodies and that of the cochlea, we might suppose that a suppurative inflammation of one of the accessory sinuses, such as the ethmoid, antrum, or frontal sinus, would be particularly prone to produce this effect. It is certainly true that many of these cases suffer from subjective noises, while the history shows that the onset was sudden, that the noise has remained unchanged for a considerable number of years, or has perhaps slightly diminished, while any impairment of hearing that existed in the early stage of the affection has disappeared. Here the inference, that embolism of one of the minute vessels has been the lesion which has produced the symptom, seems logical.

Prognosis.—Extensive destruction of the labyrinthine structures frequently follows a severe suppurative inflammation within the tympanum. When confined to a small area the condition usually improves as age advances, and although it sometimes disappears spontaneously, it is often unaffected by treatment. The lesion does not tend to progress, and either remains quiescent or slowly improves.

Treatment.—The first indication is to remove the cause, to prevent a repetition of the accident. Measures directed toward the labyrinth itself may be necessary where the affected area is extensive. The reduction of labyrinthine pressure by the internal administration of pilocarpine and subsequently of iodide of potassium is practically the most serviceable plan of treating either thrombosis or embolism. For the constant tinnitus, the use of dilute hydrobromic acid in full doses will be found to be beneficial not only in relieving the symptom, but, by reducing the degree of hyperæsthesia of the receptive centres, will often exert a certain curative effect. The drug should be given in doses of half a drachm every four hours, or more frequently if necessary. It should be well diluted with water, to avoid irritation of the stomach. Strychnine in full doses is also of value in preventing a rapid disorganization of the nerve tissue supplied by the occluded vessel both by its specific effect upon nerve tissue and its action as a cardiac stimulant.

CHAPTER XXXVIII.

SPECIFIC INFLAMMATION OF THE LABYRINTH.

Ætiology.—This portion of the receptive mechanism may be the seat of changes due to hereditary or acquired specific disease. In the hereditary cases the association of interstitial keratitis is so frequent as to point to the dependence of both conditions upon the same cause. When it occurs as the result of acquired specific disease, it is usually found in the tertiary period, although very rarely it is met with in the secondary stage.

Pathology.—The changes which are found upon post-mortem examination are of a chronic inflammatory character. The lining membrane of the semicircular canals and cochlea is thickened, narrowing the lumen of the channels, and in some instances this process has gone on to the development of new osseous tissue, causing a thickening of the bony walls of the passages. Changes characteristic of specific disease are present in the blood vessels; they consist in an obliterating endarteritis, narrowing or completely occluding the vessel lumen. From this the parts are supplied with an insufficient quantity of blood, and suffer from impaired nutrition, which may cause necrosis if sufficiently complete. Where the nutrition is seriously interfered with the parts may undergo softening, in the same manner as occurs in gummata in various parts of the body. When there is a hypertrophic process within the vestibule the newly formed bone may be deposited about the oval window, producing a thickening of the foot plate of the stapes or a synostosis of the stapedio-vestibular articulation.

Symptomatology.—The occurrence of sudden and profound impairment of hearing, with the development of subjective noises, in an adult apparently in perfect health and with no evidences of middle-ear involvement, should always excite suspicion of an underlying specific cause. The same remark applies to the sudden and unexplained appearance cf vertigo with or without any of the symptoms above mentioned. In the hereditary cases the impairment in hearing may be steadily progressive, and associated with ulceration of the cornea, as before mentioned. In children this combination of symptoms is particularly liable to occur, and, unless checked by treatment, progresses rapidly, so that the hearing power becomes almost completely lost in a short time.

Diagnosis.—The diagnosis depends upon the suddenness of the onset and the profound degree of impairment in hearing, while vertigo and vomiting may be present.

If physical examination reveals the middle ear normal, the diagnosis is rendered much more simple; when occurring in the secondary stage, an associated tubal or tubo-tympanic inflammation may be so marked as to lead the observer to suppose that the symptoms are entirely due to the condition of the middle ear, and the labyrinthine lesion may be overlooked entirely. Functional examination, however, ordinarily prevents this error. The low notes are fairly well heard even if the middle ear is involved, the lower tone limit not being elevated proportionately to the degree of impairment of hearing. The upper tone limit is very much lowered, and sharp sounds are poorly perceived, the impairment in this direction being more marked than the impairment for conversation. Bone conduction is greatly reduced or entirely absent, thus rendering the error of attributing symptoms to an affection of the middle ear almost impossible. Other signs of specific disease should also be sought for. In children, an examination of the teeth often reveals characteristic "Hutchinson teeth," while the surface of the body may present evidences of a previous specific eruption. The examination of the skin is of particular importance in adults where the disease is acquired rather than hereditary. The association of ulceration of the cornea should also be regarded with suspicion.

It may be stated in general that in cases of sudden and profound impairment of hearing or with symptoms referable to the vestibular apparatus, such as severe vertigo, these symptoms should be looked upon with suspicion, and specific disease definitely excluded. It goes without saying, therefore, that in all cases of this kind a complement fixation test by the Wassermann or Noguchi methods should be made. This examination should not only include tests of the blood, but should also include similar examinations of the spinal fluid.

The colloidal gold test of the spinal fluid should also be made in every doubtful case. It must be remembered that in cases where the aural symptoms are prominent it may not be the labyrinth or the trunk of the auditory nerve that is involved, but we may be dealing with a specific infection of the central nervous system involving either the labyrinth, the nerve trunk, the meninges, or the central nuclei. A cytological examination of the spinal fluid is also of value. In specific disease the globulins are increased and the cell count is elevated. These phenomena may exist in other intracranial complications, but their existence in specific disease must always be remembered.

Prognosis.—The difficulty in determining the value of any form of medication in these cases depends upon the fact that the disease may remain quiescent for a long period, and suddenly be excited to renewed activity by some intercurrent disease, or from no assignable cause.

We therefore can not always say whether the cessation of the symptoms occurs spontaneously or is the result of treatment. Medication is of value in recent cases without question, but in those of hereditary origin many believe that the disease can not be checked by therapeutic measures. In spite of this, no case should be considered as hopeless without having been first subjected to a thorough course of specific treatment.

Treatment.—In any case where a diagnosis of specific disease either of the labyrinth or of the central nervous system has been made, specific treatment should at once be instituted. It is not the purpose of the author to go into detail regarding any course of specific treatment. This is much better placed in the hands of those thoroughly conversant with the method of treatment to be followed out in cases of general syphilitic infection. My own plan has been, however, to particularly recommend the use of salvarsan or some similar preparation. In some cases intravenous administration of the drug is sufficient, while in others benefit is obtained only by the administration of the drug through the spinal canal. Considerable has been written about the dangers of the administration of salvarsan in these cases, and some have gone so far as to state that the drug has caused deafness in the opposite ear where at first the deafness was only unilateral, or in cases where the deafness was bilateral that the impairment of hearing has been greatly increased by the treatment. A careful study of these cases shows that these reports are absolutely without foundation. It is true that occasionally after the administration of salvarsan or some kindred drug the aural symptoms are temporarily increased. In all of these cases, however, the symptoms have ultimately disappeared upon further administration of the drug. It is supposed in those cases where the symptoms have been temporarily increased that certain spirocheta have become so deeply imbedded in the tissue as to have become inert. With the first administration of the drug these spirochetæ are liberated and produce certain symptoms. The further administration of the medication, however, results in their complete destruction and the disappearance of all the symptoms. In addition to the administration of salvarsan or some similar drug, the administration of mercury, preferably by the hypodermatic method, is of value in these cases. The administration of mercury internally in the form of bichloride or biniodide in doses from $^1/_{32}$ to $^1/_{12}$ of a grain, the use of mercurial inunctions, and the use of vapor baths are all of value. For the exact method of administration of these drugs, the reader is referred to any of the works devoted to the treatment of specific disease. The value of iodide of potassium internally in cases of this kind, especially after the use of salvarsan, and the use of mercurial preparations cannot be too strongly emphasized. If iodide of potassium is to be used, however, it must be given in large doses. It has been my custom to begin with ten or fifteen grains three times daily, and to rapidly increase the dose until the patient is taking at least one ounce each twenty-four hours. Very gratifying results have been obtained by the use of large doses of this drug, even before the discovery of salvarsan and drugs of a similar character. In cases where the disease is located in the labyrinth the use of pilocarpine either internally or hypodermatically, the drug being given until its physiological effect is obtained, and then continued at such a dosage as will insure this physiological effect, has proved of undoubted value. In order to derive the full benefit from the drug its use should be continued over a period of six to eight weeks. In cases of this character the drug should always be used in conjunction with iodide of potassium. The use of strychnine in fairly full doses is of undoubted value in some of these cases.

CHAPTER XXXIX.

INFLAMMATION OF THE LABYRINTH SECONDARY TO CHRONIC SUPPURATIVE AND NONSUPPURATIVE INFLAMMATION OF THE TYMPANUM.

Pathology.—Where the tympanic structures have been subjected for a long time to an abnormal degree of pressure from an adhesive process within the tympanum, certain changes take place within the bony capsule, both as the direct result of mechanical pressure and also from the ablation of function which this increased pressure causes. Owing to the augmentation in the tension within the labyrinth, the delicate terminal filaments of the auditory nerve in the lower part of the cochlea and in the vestibule may be completely destroyed. On the other hand, the increased tension may prevent the conduction of aërial vibrations to these nerve-end organs, and, on account of the disease in the middle ear, they may undergo atrophy from disuse, so that if the pressure is removed and the normal tension within the labyrinth is restored, they will be no longer able to perform their function. The inflammatory process within the tympanic cavity may be propagated to the adjacent labyrinthine parts by contiguity of structure. This is especially true in those cases of otitis media arising from the deposit of new connective tissue in the niche of the oval or round window. By extension, the parts beyond the foot plate of the stapes undergo similar changes; the vestibular walls become thickened, the process at first resulting in thickening of the periosteum, and subsequently in the deposit of new osseous tissue, thus encroaching upon the lumen of the vestibule. Similar changes about the round window result in an encroachment upon the lumen of the first turn of the cochlea. This process is quite characteristic of proliferous otitis media. It is also, as Politzer has recently shown, quite commonly found in advanced life, and constitutes the prominent lesion in the presbycusis.

The changes which take place within the labyrinth in chronic purulent otitis media are usually less marked than in the nonsuppurative form of the affection. Those met with in residuary cases, where the purulent inflammation has run its course, are due to pressure or disuse, or to both combined. While there is active suppuration, an actual infection of the labyrinthine structures may take place through the fenestra ovalis or the fenestra rotunda, leading to a purulent inflammation of the labyrinth. This may be transmitted, either through the blood vessels or through the aquæductus vestibuli or aquæductus cochleæ, to the meninges, and cause a leptomeningitis. In the labyrinth such a purulent inflammation results in a disintegration of the structures involved. This would mean complete destruction of the labyrinth if the entire region were affected. Fortunately, however, such an inflammation is frequently confined to the immediate neighborhood of the external labyrinthine wall, and its destructive effects are limited to the vestibular structures and to those elements lying in the first turn of the cochlea. Meningitis seldom occurs by infection through the lymph channels of the internal ear, and this of itself argues strongly against any free anastomosis between the vessels of the middle ear and those of the labyrinth immediately adjoining. Suppuration within the tympanic cavity may produce changes due to pressure alone, infection not taking place. In such an event the parts may be restored to their normal condition by treatment of the tympanic affection, and will then resume their proper function.

In addition to these structural changes, recognizable under the microscope in pathological specimens, we must remember that in many cases, probably, in which the middle ear is the seat of a chronic inflammatory process, the labyrinthine structures in the immediate vicinity of the tympanum become congested, and remain in this condition for a considerable period, without actual tissue metamorphosis. The vascular disturbances consist either of increase in the arterial supply, or a diminution of the venous outflow, augmenting the labyrinthine tension and giving rise to symptoms, although microscopic specimens would reveal no structural changes. We are warranted, however, in the supposition that these conditions are present from the history of certain cases.

Symptomatology.—The exact line of demarcation between symptoms dependent upon middle-ear or labyrinthine changes can not be drawn. All symptoms of impairment or perversion of function must, strictly speaking, be relegated to the perceptive tract, and it is difficult to say when they are produced by mechanical irritation simply, from alterations in the tension of the conducting apparatus, and when certain changes have actually taken place in the labyrinth itself. The most constant symptom is undoubtedly the presence of subjective noises. In the early stages of a nonsuppurative otitis media the persistence of tinnitus should be looked upon as an indication that the labyrinth is at least congested, and, unless prompt measures are taken for the relief of the condition, must soon become the seat of organic changes. The subjective noises vary in character and in intensity. At first they are intermittent, occurring chiefly when the recumbent position is assumed, as this posture favors a determination of blood to the head. In neurotic individuals any severe nervous strain, or even physical exertion, will serve to increase them. The same is true of impairment of the general health, or asthenia following a severe illness.

When these noises are intermittent, and due chiefly to congestion, they are frequently synchronous with cardiac pulsations; but as the disease advances this pulsating tinnitus diminishes, and is replaced by a constant high-pitched musical sound as the lower portion of the receptive tract becomes involved. These patients also complain that, in addition to this high-pitched musical note, they hear at irregular intervals loud, low-pitched sounds, variously described as rumbling, roaring, thumping, or booming noises. We may surmise that these are produced by changes within the cristæ acusticæ. In those cases where the tympanic process is confined chiefly to the region of the oval or round windows the interference with sound transmission may be so slight as to occasion very little impairment in the hearing, and the subjective noises may constitute the sole symptom of which the patient complains, the labyrinthine structures being involved at a very early period. As the process advances, the subjective noises change their character, becoming of lower pitch, and finally they may disappear entirely, owing to a complete destruction of the nerve filaments. This same general train of symptoms is occasionally met with in cases of chronic suppurative inflammation where the process is still active, or in residuary cases, but is always present to a much less degree than in the instances of hyperplastic otitis media. The reason for this is probably twofold, the first being that the process within the tympanum has been followed by destruction of portions of the conducting mechanism, and increased labyrinthine tension may be present to only a very slight degree. As a second reason, we should remember that the inflammatory process within the labyrinth itself is not of such a character as to lead to the deposit of new tissue, but to an increase in the amount of perilymph. This increase takes place slowly, and is compensated for by the passage of the fluid outward into the endocranial lymphatic spaces.

In addition to the tinnitus, disturbance of the equilibrium is frequently complained of. This points to the invasion of that portion of the labyrinth in immediate relation with the semicircular canals, as well as involvement of the canals themselves. The vertigo may be constant or intermittent, occurring only upon some sudden change in the position either of the entire body or of the head, or it may be due to visceral disturbances. Sudden changes in intratympanic pressure do not under normal conditions cause vertigo; but when the apparatus which presides over the static condition of the body is in unstable equilibrium, even a slight disturbance may cause giddiness. A sudden closure of the Eustachian tube—the result of an acute rhinitis or naso-pharyngitis—or a powerful effort at blowing the nose, or a severe fit of coughing, may so alter the pressure as to bring on an attack of dizziness. Any process which suddenly increases the blood pressure within the labyrinth is capable of bringing on vertigo. Here we may mention violent exercise, suddenly lowering the head in stooping, intense mental excitement, as either rage or grief, etc.

The vertigo seldom persists, but disappears in late stages of the disease. The impairment of hearing varies greatly in degree, and the subjective symptoms may cause the patient to seek relief before he has noticed any change in the power of audition. The reason of this is that the perception of the highest notes of the musical scale is of little use in the ordinary vocations of life, and conversation may be perceived without difficulty, although the upper tone limit is considerably lowered.

The clinical history detailed above presupposes the involvement of but one ear. Sooner or later the organ of the opposite side becomes involved, and then the impairment in function becomes decidedly noticeable and increases with great rapidity. The balance of evidence at present seems to favor the view that the involvement of the ear of the opposite side is due to an extension of the process from the one first attacked, rather than that it is dependent upon an inflammatory process similar in character but of primary origin. This extension can readily be understood if we remember the crossing of the fibres of the eighth nerve in the medulla, through which the cortical auditory region receives fibres from the labyrinth of either side, but chiefly from the opposite labyrinth. An involvement of this principal terminal apparatus would cause degenerative changes to take place in the centre itself. These, in turn, would excite certain disturbances in that portion of the cortex deriving its supply from the nerve of the side corresponding to the cortical area, thus ablating the function of this portion of the cochlea of this side. Clinical observation shows that in a large proportion of cases of hyperplastic otitis media, with complicating labyrinthine involvement, the labyrinthine changes in the ear last affected are more extensive than those in the organ first involved. Of twenty-six of my own cases, sixteen exhibited this condition.* The tympanum also becomes involved secondarily, but to a much less extent than the labyrinth, and the impairment of function seems to be due chiefly to the labyrinthine changes. These alterations occur so rapidly that the patient not infrequently presents with the history that the ear first involved is at present of the most use to him. It is of great importance to obtain a correct history of the case, and we should learn definitely, if possible, in which ear the impairment of hearing began, and at what period. Unless great care is taken to obtain these data a grave error may be made.

After the terminal filaments of the auditory nerve have been the seat of changes for a considerable period, the subjective noises, which were at first distressing, become less severe, owing to the complete ablation of function of this portion of the cochlea. The spontaneous cessation of tinnitus in one ear furnishes a clew to the information desired, and it is usually the case that the organ first involved causes less distress from this cause than does its fellow. Where the tympanic process is marked in the ear last involved, the symptoms differ in that the impairment of hearing is usually about equal upon the two sides, or audition is perhaps slightly better upon the side last involved.

---

* New York Eye and Ear Infirmary Reports, 1894, vol. ii, p. 62.

Diagnosis.—A. *Physical Examination.*—Upon inspecting the ear we have presented a picture of chronic catarrhal inflammation, or the various changes resulting from a suppurative process. In the nonsuppurative variety the parts may vary but little from the normal standard, as far as appearances are concerned, the reason being that the pathological changes take place mostly at the oval and round windows. The more external parts of the conducting mechanism may be but little affected. The color, density, lustre, and position of the drum membrane may be within normal limits, provided the changes have been hyperplastic from the start. In those cases secondary to a hypertrophic process the position of the drum membrane is usually abnormal; it is commonly retracted to a greater or less degree, and presents variations in density in different areas, while the breadth of the malleus handle is either greater or less than under normal conditions, from a rotation of this ossicle upon its long axis. This has been fully described in a previous chapter.

Where the internal ear is involved as the sequel to a suppurative inflammation which has run its course, the appearances vary according to the amount of destruction which has taken place. The postero-superior quadrant is the region to be particularly inspected as throwing light upon the probable cause of the involvement of the perceptive portion of the auditory system. We may find the stapes forced deeply into the oval niche and fixed by adhesions, which bind the crura firmly to the borders of the pelvis ovalis, or a tense posterior fold may cause a similar condition. The niche of the round window is quite frequently in view, and should always be examined for adhesions, as these may play an important part in the production of the symptoms. Where the stapes has become separated from the incus, during the course of a suppurative inflammation, the condition of the other ossicula may be practically disregarded, since the structures within the pelvis ovalis and niche of the round window alone affect the condition of the labyrinth. In the nonsuppurative cases it is important to determine whether the middle-ear affection has become quiescent, or whether it is still active and progressive. To decide this definitely is often impossible; although hyperæmia at the inner extremity of the bony meatus, close to the tympanic ring, may usually be looked upon as an evidence that the tympanic affection is still active, while, if the parts are pale, the process is probably quiescent, and the labyrinthine changes are not liable to be augmented by the further progress of the middle-ear lesion.

B. *Functional Examination.*—The hearing is impaired both for sharp sounds and for whispered or spoken words. It may be roughly stated that where the labyrinthine involvement is extensive, sharp noises are relatively more poorly heard than speech, the converse being true when a tympanic affection predominates.

The lower tone limit is elevated, the upper tone limit reduced, the degree varying with the extent of the labyrinthine lesion; bone conduction is decidedly diminished or may be entirely absent. Rinne's experiment will be negative for the lower notes of the scale, becoming positive as the test is made with the higher forks. It is now important to determine in any given case how much of the impairment depends upon the condition within the tympanum and how much upon the secondary labyrinthine changes. If we compare the degree of defective audition for whispered or spoken words with the point in the musical scale at which Rinne's experiment becomes positive, we have an estimate of the relative amount of middle-ear and labyrinthine involvement. Where this point lies high in the musical scale in cases where the function is impaired to a marked degree, we are warranted in the conclusion that the chief trouble lies within the tympanum. Confirmatory of this we find the upper tone limit but slightly lowered, and bone conduction either normal or but little impaired. Naturally the age of the patient must be taken into account in drawing these deductions. If, on the other hand, we have to deal with a patient who hears the whisper only when the words are repeated close to the ear, and Rinne's experiment becomes positive in the lower portion of the scale, the tympanum is not the part most involved. In such an instance we should expect to find a marked lowering of the upper tone limit, and poor bone conduction. In deciding this question, it is well to make several examinations, since any sudden disturbance within the tympanum causing a temporary increase in labyrinthine pressure might mislead us. The results obtained from functional examination conducted in this manner, taken in connection with the history of the case, the age of the patient, etc., will seldom fail to render the diagnosis clear. Certain symptoms of which the patient complains, such as the cessation of subjective noises, the presence or absence of paracusis Willisii, evidences of auditory fatigue, and marked variations in the hearing power dependent upon meteorological changes, are also of value. With reference to this last symptom, I feel certain that variations following changes in the weather are quite as characteristic of an affection of the cochlea as of one of the middle ear. This point has been sufficiently considered in a previous section.

The reaction of the auditory nerve to electrical stimuli is of diagnostic value. If a hyperæsthetic condition is present, this denotes activity or progression of the disease, but does not locate it definitely, since this hyperæsthesia may depend upon the excitation of the terminal filaments by a progressive tympanic inflammation, or it may be the result of an active process within the labyrinth. The inspection of the parts will usually enable the surgeon to decide whether the tympanic inflammation is active or quiescent, and in this way to determine the cause of the hyperæsthesia.

It should be the rule to investigate both ears with equal care, otherwise incipient involvement may be overlooked. Galvanic hyperæsthesia upon one side may depend upon inflammation of the opposite tympanum.

Prognosis.—Any implication of the peripheral filaments of the auditory nerve, secondary to changes within the middle ear, constitutes in every case a grave condition. The ultimate result must be considered both with reference to the further progress of the disease and to correcting the effects already produced. In the cases following a destructive inflammation within the tympanum, a steady advance of the symptoms is seldom looked for. We occasionally meet with instances in which a preceding suppurative otitis media affecting one side only, produces late in life certain disturbances in the organ upon the opposite side. When this occurs the prognosis as regards the healthy ear is of chief moment, the other organ having been practically useless for a long time.

If unchecked by proper measures a steady advance must be expected. In nonsuppurative cases the involvement of one ear is followed sooner or later by a corresponding process upon the opposite side. In unilateral cases, if we can do nothing to improve the condition of the affected organ, the early adoption of measures directed to the removal of its effect upon the opposite ear may stop the progress completely. In bilateral cases we may usually assume that where the tympanic disease predominates upon the side first involved, its proper treatment will not only improve the function of both organs, but will stop the progress of the disease completely. With regard to the progress of the labyrinthine lesion in the organ first affected, this, almost without exception, advances, unless checked artificially, until the function of the ear is entirely ablated. The probable result of treatment will depend upon the extent to which the process has advanced before the case comes under observation. Where we judge that a comparatively small portion of the cochlea is involved, we may hope to restore the function to a great degree. If extensive changes have taken place, complete retrogression must not be hoped for. But a considerable amelioration of the symptoms may occur even in cases of long standing. In general, those cases dependent upon suppurative disease are much more favorable than those where connective-tissue hyperplasia has occurred primarily.

Treatment.—First of all we must remove any condition within the tympanum which might cause labyrinthine changes. In other words, treatment directed to the middle ear is not contraindicated in instances of mixed disease, except in cases where the labyrinthine condition is the most prominent feature and has existed for so long a time as to render its relief impossible even if the tympanic lesion could be overcome. Adhesions must be absorbed or divided according to their density. In suppurative cases surgical measures are practically the only ones at our disposal, and the stapes and the membrane about the round window must be relieved of any increased tension. Tense bands must be divided according to the principles of aseptic surgery, and this process continued until the niche of the oval and round window is perfectly free. In the nonsuppurative cases surgical measures may be called into requisition, although here with less promise of success than in the preceding instances.

This subject has been thoroughly dealt with under Middle Ear Operations, and need not be repeated. The procedures are to be instituted both for the organ first affected and for its fellow of the opposite side. Concerning the administration of drugs, pilocarpine seems to be the remedy best adapted to these cases. It is to be administered preferably by the mouth, beginning with doses of one eighth to one sixth of a grain twice or three times daily, the amount to be increased according to the toleration of the patient. If benefit is to be obtained, the constitutional effects of the drug must be produced, and its administration continued for a period of two months, and in many cases longer. No improvement should be expected under two weeks or a month, and it is frequently delayed beyond this time.

Where one ear has been considered useless by the patient for many years, a condition of torpidity of the auditory nerve and corresponding centres manifests itself. This is best combated by the administration of strychnine in full doses, beginning with one fortieth of a grain three times daily, increasing to one twentieth or one fifteenth if the drug is well borne. This drug may be advantageously administered in connection with pilocarpine.

Where there is a history of either hereditary or acquired specific disease the iodides in full doses frequently produce remarkable results. Much has been written of late upon the treatment of these cases by sonorous vibrations by means of the phonograph or some similar instrument. This form of treatment is by no means new, the idea being mentioned by Toynbee,* who reports a case of great improvement following the use of the conversation tube for a considerable period of time. In this instance the human voice was the agent employed. Later, tuning forks were used for the same purpose, the fork being maintained in vibration before the patient's ear for a certain length of time, and effecting both massage of the rigid ossicular articulations and stimulation of the auditory nerve itself. The employment of the phonograph, vibrophone, vibrometer and similar devices for effecting the same result, is merely an application of this principle, the apparatus used being of little importance.

There is evidence to show that by following this plan subjective noises are reduced in intensity and the hearing in certain cases improved. For a considerable period of time I have advised the use of some simple form of conversation tube, the patient being read to by an attendant for perhaps ten or fifteen minutes twice daily, in a tone of voice that can be easily perceived. Any words which are not clearly heard should be repeated distinctly at least ten times. In this way the torpidity of the receptive centre is overcome and the patient learns to interpret correctly the words which he hears, although they may not be perfectly heard. The process is exactly similar to that of a child learning to talk, or of an adult learning a foreign language, the sensorium being really educated so as to correctly interpret the perverted auditory stimuli.

---

* Diseases of the Ear, p. 433.

The relief of subjective noises seldom forms a prominent indication for treatment in cases of advanced labyrinthine disease. Where these are distressing, however, a period of temporary relief may usually be obtained by the administration of large doses of hydrobromic acid, and it is wise in all cases to employ this drug when the noises first appear. If they are allowed to continue, the higher centres become so irritated that the removal of the primary cause of the disease may fail to relieve this distressing symptom completely. Concerning the effect of climate upon the progress of the affection but little is actually known, and I have never considered the matter of climate of sufficient importance to insist upon a change of residence for the aural affection alone. Of much more importance is the general condition of the patient. Overfatigue, mental strain, irregularities in diet, or the excessive use of stimulants must be positively interdicted. The employment, except when it is imperative, of any drugs—such as quinine or salicylic acid—which are known to cause an intense congestion of the labyrinth, must also be forbidden, since their ingestion, even in small doses, may excite the process to renewed activity. Diathetic conditions must be controlled, particularly those of a gouty or rheumatic character.

CHAPTER XL.

LABYRINTHINE SUPPURATION.—ACUTE INFLAMMATION OF THE LABYRINTH SECONDARY TO ACUTE OR CHRONIC PURULENT OTITIS MEDIA.

Ætiology. —This form of inflammation of the labyrinth is usually confined to those cases in which the middle-ear affection depends upon an acute infectious disease, such as scarlet fever, diphtheria, measles, epidemic influenza, cerebro-spinal meningitis, or typhus fever. It may follow a severe attack of suppurative otitis media, developing from exposure to cold, from a traumatic cause, such as the accidental introduction of fluid into the tympanum, or rupture of the membrana tympani. The disease may follow either an acute or chronic middle-ear suppuration. Its occurrences in child life may be explained from the fact that the internal wall of the middle ear is less dense at this time than later in life. In order that the entire auditory mechanism should be involved in an inflammatory process, the infection must be of great virulence, and this depends upon the severity of the acute infectious disease.

Pathology.—This condition has been called, not inappropriately, *panotitis.* As the result of infection within the middle ear the softer structures rapidly break down, while the firmer osseous tissue becomes carious, and are either completely destroyed or suffer a considerable loss of substance. The periosteum covering the inner tympanic wall takes part in these changes, and not infrequently an acute inflammation of the underlying osseous tissue results. The propagation of the condition to the labyrinth may take place either directly through the diseased bony wall or at the labyrinthine windows. Post-mortem examination frequently shows a destruction of the membrane of the round window, or a loss of substance at the stapedio-vestibular articulation, the infectious material having entered through these channels. The tissue changes which take place do not differ from those observed in the middle ear. Microscopic investigation reveals the presence of the bacilli of suppuration both in the blood vessels and in the tissues. Local necrosis occurs early, and the firm osseous tissues either disintegrate and are thrown off in the profuse secretion incident upon the inflammatory process, or the necrosis may result in the formation of a sequestrum, which is either discharged spontaneously or is removed by surgical interference. The condition may extend from the labyrinth to the meninges, either along the sheath of the auditory nerve or through the vestibular or cochlear aqueducts, causing either a purulent or serous meningitis. These extensive changes may cause partial or complete destruction of the end organ of the auditory nerve. During the reparative process new osseous tissue may be deposited and obliterate the labyrinthine cavity to a greater or less extent.

Symptomatology.—Occurring in young subjects most frequently, the symptoms depend upon the intense systemic infection rather than upon the involvement of the terminal portion of the auditory apparatus. The involvement of the labyrinth in consequence of an acute process within the middle ear announces itself in older subjects by the sudden appearance of giddiness, tinnitus, and impairment of hearing. A sudden invasion of the labyrinth is usually characterized by a rather abrupt rise in temperature. In my own cases, I have never seen the temperature rise above 101°, although, in the very acute cases, the temperature may go to 104°. The pulse is ordinarily correspondingly rapid. A persistence of the high temperature is usually followed by the development of meningeal symptoms, due to the extension of the inflammatory process along the sheath of the auditory nerve to the meninges. When the inner tympanic wall becomes involved in this manner, facial paralysis is not uncommon, owing to a partial destruction of the aquæductus Fallopii, exposing the facial nerve to infection. Occasionally dehiscences are found in the osseous covering of the facial nerve when there has been no pathological process, in which case a simple inflammation of the middle ear produces this symptom without causing a loss of substance in the wall of the aquæductus Fallopii. Hence, facial paralysis alone is not necessarily an evidence that the disease has involved the bony walls. The interference with equilibrium may depend upon the entrance of the infectious material into the vestibule, or the horizontal semicircular canal situated high up on the inner tympanic wall may be the seat of involvement; in the latter case disturbance of equilibrium alone is present, while the function of audition is scarcely perverted or interfered with.

The most usual avenue of extension is through the horizontal semicircular canal, with involvement of the vestibule. An inflammatory process in this location produces the characteristic symptoms first mentioned, namely, vertigo, tinnitus, and impairment of hearing. The vertigo in these cases may be so severe as to confine the patient to bed, or may be slight, and may only be elicited by careful examination. The tendency of the patient is usually to fall toward the healthy side. The vertigo may be present only when the patient attempts to walk with the eyes closed, or as demonstrated by von Stein,* the vertigo may only be pronounced when the patient attempts to jump forward or backward with the eyes closed. Another symptom characteristic of the condition, is nystagmus. Nystagmus may be either lateral or rotary, but is usually most marked when the eyes are turned toward the healthy side. In some cases I have seen the nystagmus present when the eyes were turned toward the diseased side as well, but the symptom is usually more exaggerated when the eyes are turned toward the healthy side.

Since the petrous bone lodges the internal carotid artery severe hæmorrhage from the ear may be a symptom of this extensive destruction. If the carotid is eroded this hæmorrhage is usually fatal. From the proximity of the cranial contents direct infection of the meninges may follow, with the characteristic symptoms of meningitis. It is probable that a localized inflammation of the labyrinthine structures in the immediate neighborhood of the fenestra rotunda sometimes occurs, without spreading to the entire labyrinth. In those cases which do not terminate fatally, the hearing for the upper portion of the musical scale remains greatly impaired, and there is but little promise of a favorable termination under any plan of treatment. A portion of specialized end organ of the auditory nerve has been completely destroyed by the disease, and manifestly can not be regenerated by therapeutic measures. Any portion of the cochlea which has remained intact may still respond to the stimuli of sonorous vibrations, and the removal of certain conditions which interfere with its proper action may preserve the remnant of the auditory function.

Diagnosis.—A. *Physical Examination.*—Speculum examination reveals but little in these cases. The picture is one of a suppurative otitis media of great severity, and in the early stages this is all that can be made out. At a later period the presence of carious bone gives rise to the formation of exuberant granulations in the tympanic cavity, while careful examination with the probe may reveal denuded areas upon the inner tympanic wall. The profuse discharge is also indicative of extensive tissue necrosis. Careful examination of the gait and the appearance of the nystagmus on examination of the eyes are also valuable aids in diagnosis. According to the investigations of Barany,* if, under normal conditions, one ear is syringed with cold water there will be produced a nystagmus toward the opposite side. This symptom is more pronounced when the drum membrane is wanting than in cases where it is intact. If the labyrinth is destroyed, syringing with cold water will produce no nystagmus. The employment of this test is, therefore, of value in doubtful cases, as determining labyrinthine involvement. The test is particularly valuable in making a differential diagnosis between a cerebellar abscess and involvement of the labyrinth. With destruction of the labyrinth, spontaneous nystagmus occurs toward the healthy side, and the reaction on syringing with cold water would be negative. In case of a nystagmus directed toward the affected side with a negative reaction to syringing with cold water, labyrinthine lesion can be excluded, and the lesion must lie in the cerebellum.

---

*Transactions of the 7th International Otological Congress, Bordeaux, 1904, p. 297.

B. *Functional Examination.*—In young subjects an examination of this kind is manifestly impossible. Occurring in patients of sufficient age to answer questions intelligently, it is often of great service in enabling us to determine the presence or absence of the condition in question. Bone conduction is usually diminished, but owing to the fact that the internal ear structures are not completely destroyed in this condition, this diminution in bone conduction may not be marked. In two cases of extensive destruction of the labyrinth, I have found the tuning-fork placed on the vertex referred to the affected side, although absolute bone conduction was somewhat diminished. The upper-tone limit is usually lowered, although this lowering may not be very great. If we add to this loss of perception of high musical notes the diminished bone conduction and the intense vertigo, we have a combination of symptoms which can mean nothing but labyrinthine involvement.

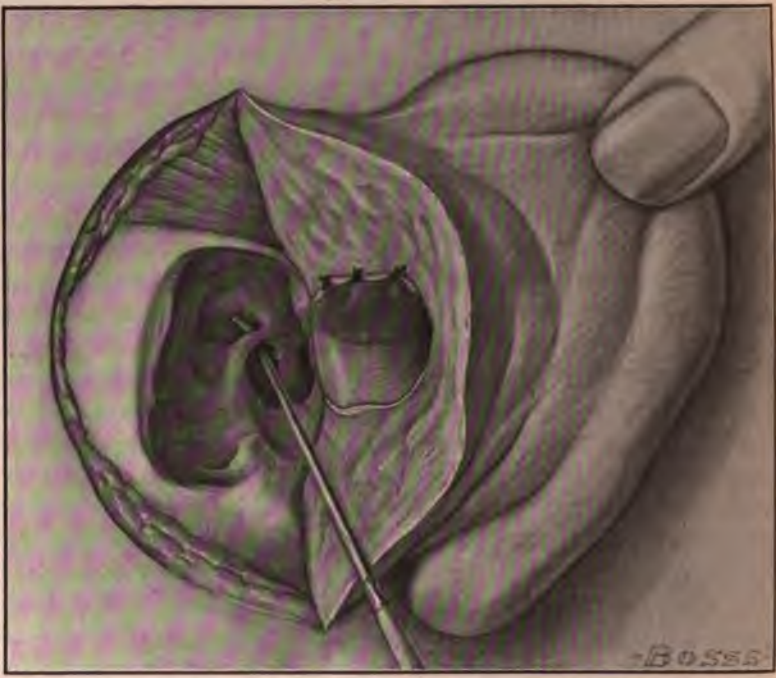
---

* "Untersuchungen über den vom Vestibularapparat des Ohres reflektorisch ausgelösten rhythmischen Nystagmus und seine Begleiterscheinungen." Monatsschrift für Ohrenheilk., 1906, vol. xl.

Prognosis.—The prognosis is absolutely unfavorable as to the complete restoration of the function of the organ, although considerable useful hearing may remain. As to life, the outlook is grave, especially in young subjects. In adults, extension to the meninges is less common, and a favorable termination may be hoped for. Much depends upon the degree of infection, and this varies with the disease which has caused the inflammation within the tympanum. Complete ablation of audition is less liable to take place in adults than in children, but considerable interference with function must always be looked for. At an early age this termination means deaf-mutism, and it is our duty to bear this in mind in giving an opinion.

Treatment.—The treatment of the condition should be at first prophylactic. This consists in the proper treatment of the acute otitis, securing free drainage by early incision of the drum membrane, and the prompt opening of the mastoid process in cases where free drainage of the middle ear is not efficient in controlling the suppurative process. The possibility of involvement of the labyrinth in every case of acute inflammation should always be borne in mind, and should prompt the surgeon to resort to surgical interference early. After the labyrinthine symptoms have appeared, if the fever continues more than twenty-four or forty-eight hours, the radical operation should be performed in order that the labyrinthine walls may be examined. The region of the horizontal semicircular canal and of the oval and round windows should be carefully inspected. An erosion may sometimes be discovered over the horizontal semicircular canal, this constituting the path of infection. In other cases the oval window may be found open and a probe may be passed directly into the vestibule. In chronic cases we sometimes find the footplate of the stapes wanting, and the oval window filled with granulation tissue. When any of these conditions are present, free drainage of the labyrinth should be secured. This is best effected by opening the horizontal semicircular canal at its most prominent part, the convexity of the canal being removed so as to obtain free access to its lumen; the canal is then followed to the vestibule. The vestibule is thus opened where the horizontal semicircular canal joins it, and the opening is enlarged downward so as to freely drain the vestibule. Next, the oval window should be enlarged downward and forward, so that the vestibule may be drained into the middle ear. In carrying out this procedure the curette or gouge is so applied as to remove that portion of the promontory which lies between the oval and the round window. It is necessary to remove a portion of the lower turn of the cochlea, in order to effect free drainage. When the operation for draining the vestibule has been completed, a probe may be passed through the oval window, upward and backward, so that it will emerge through the opening in the horizontal semicircular canal. Care must be taken to leave the thin bridge of bone above and behind the oval window, as this bridge of bone lodges the facial nerve, and destruction of this bony canal often leads to facial paralysis. If care is exercised this bony bridge can usually be preserved and the facial nerve will remain intact. In cases where, during the radical operation, a small sinus is found in the horizontal semicircular canal, and no labyrinthine symptoms have been present, it is then, usually, only necessary to remove this carious area, and complete drainage of the vestibule is not necessary. It is only when labyrinthine symptoms present themselves that the internal ear should be drained in the manner described. Where the disease affects the cochlea, no attempt should be made to remove the entire cochlea, but only the lower turn of the cochlea, and possibly the second turn should be drained by the removal of the outer wall. Particular care should be used not to open the apex of the cochlea, as in this way the modiolus is destroyed, and infection of the cerebro-spinal fluid through the internal auditory meatus may take place. Only the lower turn and the second turn of the cochlea should be removed. After the labyrinth has been drained in the manner described, a strip of gauze should be inserted into the enlarged oval window and a second into the opening in the horizontal semicircular canal, thus draining the labyrinth as completely as possible. The large bony cavity resulting after the radical operation should be treated according to the rules already laid down in describing the radical operation. Naturally, primary grafting should not be done where the labyrinth has been opened. In drainage of the labyrinth by the Neumann method the dura in the middle fossa is exposed, the lateral sinus is exposed, and then the entire semicircular canal system is removed by taking away the bone in the triangle bounded above by the exposed dura, behind by the lateral sinus, and

PLATE XVI.



OPERATION FOR SUPPURATIVE INFLAMMATION OF THE LABYRINTH.

This plate shows the complete radical operation, with ablation of the posterior, horizontal, and superior semicircular canals, with drainage of the vestibule posteriorly. The oval window has also been enlarged downward and forward, so as to drain the vestibule anteriorly. The curved sound is passed through the enlarged oval window upward and backward into the vestibule, passing beneath the bridge of bone which lodges the facial nerve. (Author's dissection.)

in front by the facial ridge. All bone excepting the thin ridge containing the facial nerve is removed. This drains the semicircular canals and vestibule. The cochlea is drained exactly as in the preceding operation. See plate xvii.

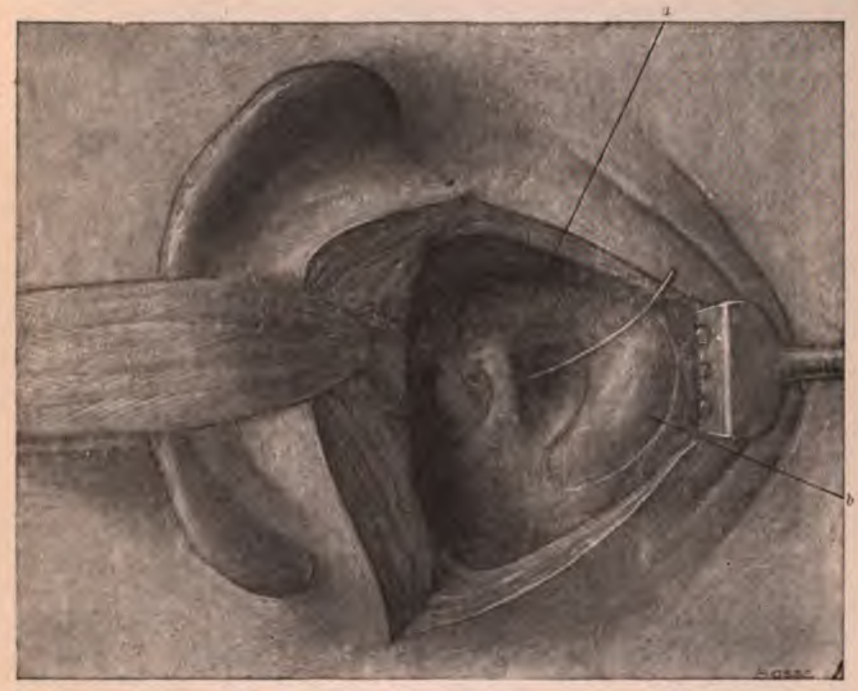
CHAPTER XLI.

INVOLVEMENT OF THE PERCEPTIVE MECHANISM IN THE ACUTE INFECTIOUS DISEASES.

DURING the course of scarlatina, diphtheria, measles, mumps, typhus or typhoid fever, variola, influenza, etc., the organ of hearing is not infrequently the seat of marked pathological changes. In scarlet fever, diphtheria, measles, and influenza, and to a less degree in variola, the middle ear is the part first attacked in most cases, and any labyrinthine involvement is due to an extension of the tympanic inflammation. We meet with instances, however, in which the specific poison exerts a direct influence upon the labyrinth, in some cases the middle ear remaining healthy, while in others there has evidently been a double infection, the labyrinthine process in no way depending upon the changes which have taken place in the tympanum.

Pathology.—In the diseases already enumerated the poison is conveyed to the labyrinth through the blood current, and excites an inflammation of the tissues which line its bony channels, in some cases causing a disintegration of a large portion of the terminal apparatus of the auditory nerve, while in others the local process does not reach this degree, but results in an effusion of fluid into the labyrinthine cavity, with the result of increasing the tension upon the contained parts, as well as of the membranes covering the round and oval windows. If the effusion is sufficient in amount to overcome the elasticity of these limiting membranes, the function of the labyrinth is for a time perverted, particularly for those parts lying immediately in the neighborhood of the round and oval windows. It is probable that the small capillary channels of the aqueducts which permit any excess of perilymph to pass into the intracranial lymph spaces are partially occluded, and hence relief to pressure in this direction is impossible. Under these conditions the disturbance of function depends entirely

PLATE XVII



Operation for Opening the Vestibule According to the Neumann Method, Modified by the Author.

The auricle is seen drawn forward and the customary auricular flap stitched in position: *a*, Represents dura exposed over middle fossa; *b*, lateral sinus exposed. Note that the dura in front of sinus is exposed for a considerable distance. The probe is seen in position entering the vestibule posteriorly and passing beneath the facial ridge, forward and outward, through the opening made by opening the first and second turns of the cochlea (author's dissection).

upon the invasion of the labyrinthine cavity, even although the middle ear may have been the seat of changes as well.

Symptomatology.—These cases are characterized by varying degrees of impairment of hearing and rather moderate subjective noises. In the milder cases in adult life the patients hear more poorly in a noise than in a quiet place. The impairment of hearing is particularly marked in general conversation. In other instances, and when the primary disease which has produced the condition has been severe, a high degree of deafness is present, the voice being heard only when the patient is spoken to loudly in the immediate vicinity of the ear. The exanthemata are particularly prone to affect the organ of hearing in this way, and are most common in childhood; at this age such a condition must lead to mutism unless speedily remedied, and the recognition of the nature of the process is of greater importance in childhood on this account.

Diagnosis.—The diagnosis in these cases depends upon the fact that the middle ear is either perfectly healthy, or presents changes which are evidently incapable of producing the degree of functional impairment present. The functional examination is characteristic of labyrinthine changes rather than of those met with in a lesion of the conducting apparatus. The lower tone limit may be normal or but slightly elevated, even although extensive changes have occurred within the tympanum. The upper tone limit is greatly lowered; bone conduction reduced in spite of the presence of a tympanic lesion, or nearly absent where the tympanum is in a healthy condition. Not infrequently tone gaps are present in the upper portion of the musical scale.

Prognosis.—When changes are of recent origin, we are warranted in believing that considerable improvement may follow proper therapeutic measures, and in cases of long standing it is by no means impossible to improve the condition very materially. In childhood, particularly, internal medication is followed by the happiest results, and the patients should always have the benefit of the doubt, even although the case may seem apparently hopeless.

Treatment.—For the reduction of labyrinthine pressure and the absorption of the exudation, the administration of pilocarpine first in small doses—the amount being rapidly increased as the patient becomes accustomed to its use—

causes a marked improvement in the hearing, and the improvement is usually permanent. In cases of long standing the torpidity of the nerve is to be combated by the use of strychnine as well. This drug must be administered in much larger doses than those ordinarily recommended in order that this effect may be produced. An additional indication for its administration is to combat the depression which the prolonged use of the pilocarpine frequently causes. It is scarcely necessary to say that the most careful attention must be paid to the general condition of the patient, and in the case of children every effort is to be employed to educate the power of audition as it improves.

Having considered involvement of the perceptive apparatus in acute infectious diseases from a general point of view, a few remarks may not be out of place in regard to some of the particular changes following certain of these maladies.

MUMPS.

Epidemic parotiditis is particularly prone to affect the labyrinthine structures rather than the middle ear. Recent investigations seem to prove clearly that this local inflammation is due to infection from the blood current in precisely the same manner as in a complicating orchitis. The effect upon the perceptive apparatus is usually very profound, and its occurrence in early life is a not infrequent cause of deaf-mutism.

The symptoms detailed above are all characteristic of labyrinthine disease dependent upon this cause. The same is true of the diagnostic measures employed and the therapeutic means at our disposal.

Regarding the prognosis in these instances, treatment is followed by the happiest results if instituted early. When the patient does not come under treatment until a considerable time has elapsed, the complete restoration of function can not be hoped for, although moderate improvement may be expected.

TYPHUS AND TYPHOID FEVER.

In typhus or typhoid fever interference with sound perception is probably due to the changes which the specific poison of the disease causes in the cerebrum itself rather than to any effect upon the terminal filaments of the nerve. That this is the case seems to be borne out when we consider the degree of impairment of hearing which these patients frequently present, and its disappearance during the period of convalescence.

EPIDEMIC INFLUENZA; DIPHTHERIA.

In epidemic influenza, and in some cases of diphtheria, it is probable that the perceptive apparatus occasionally suffers through changes in the auditory nerve trunk similar to those occasionally found in the optic nerve following these diseases. These are of the nature of a peripheral neuritis, and involve the nerve trunk to a varying degree. As a result, sclerotic changes occur with atrophy of the nerve fibres.

The interference with function will depend upon the extent of the lesion, and the possibility of restoring the parts to a normal condition will depend upon the same fact. The condition is characterized by an interference with the perception of the middle notes of the musical scale, the tone limits remaining normal. Bone conduction is not destroyed completely, although it is much diminished. The galvanic irritability of the nerve is usually increased.

The treatment should be directed toward the improvement of the general condition of the patient. Mental and physical rest should be secured. The food should be of the most nourishing quality, while the general neurasthenic condition should be combated by the administration of strychnine. After the acute symptoms have subsided, this drug should be given in large doses, to secure its well-known specific effect upon the nerve tissues.

EPIDEMIC CEREBRO-SPINAL MENINGITIS.

Pathology.—In scarlet fever, diphtheria, measles, mumps, typhus and typhoid fever, variola, epidemic influenza, etc., the primary invasion of the labyrinth occurs by direct infection through the blood current. When the meninges are invaded by the specific germ of the disease under consideration, the inflammatory process extends along the lymph channels of the vestibular and cochlear aqueducts, and involves the structures located within the bony labyrinth. During the early stages both the perilymph and endolymph are increased in quantity, while at the same time their composition undergoes a change through the action of the specific germ. Later, the bony walls are the seat of inflammatory changes. Both the arteries and veins become dilated. There is a migration of white blood cells into the surrounding tissues, and true tissue hypertrophy takes place. From the extensive proliferation of the blood vessels themselves in the newly deposited tissue, the walls of these channels are of unusual tenuity and rupture easily. Hence extravasation of blood constitutes one of the conditions found. The newly deposited tissue increases in density, and may be transformed into bone, in which case the semicircular canals or cochlea are partially or completely obliterated. In other portions the chief force of the disease expends itself in tissue necrosis; the labyrinthine channels being filled with pus. Occasionally the tympanum is invaded secondarily by a rupture of the membrane at the round or oval windows, allowing the inflammatory products to escape into the middle ear. From the tympanic involvement the drum membrane is soon destroyed, and a purulent otorrhœa manifests itself. Naturally this condition is somewhat rare, as death usually takes place before sufficient time has elapsed for its completion.

Symptomatology.—In addition to the symptoms characteristic of meningeal inflammation, we have vertigo, sudden loss of hearing, and intense tinnitus. In very young children the vertigo may be the only evident symptom, on account of the age of the patient. Occurring in older individuals, the access of subjective noises is usually sudden, while their intensity is so great as to be agonizing. The hearing is either completely destroyed at once, or this condition occurs at the end of a few hours after the appearance of the symptoms. Preceding these marked evidences of labyrinthine invasion, the power of audition may be abnormally acute, probably from the hyperæmic condition of the labyrinthine structures. This hyperacusis may be so marked that faint sounds even are painful, the patient starting at the slightest noise, and complaining of an increase in the headache characteristic of meningitis. After a short time the subjective noises diminish, owing to the destruction of the terminal filaments of the eighth nerve, and the hearing remains profoundly impaired for the same reason. The power of equilibrium gradually returns, although this is more slow, perhaps, than the disappearance of the subjective noises. The involvement of the middle ear is evidenced by the ordinary symptoms of an acute purulent inflammation arising from any other cause.

Diagnosis.—A. *Physical examination* is of importance in that it yields absolutely negative results, the membrana tympani and meatus presenting a normal appearance. From the absence of any deviation from the standard of health, together with the presence of subjective symptoms referable to the ears, suspicion is naturally directed toward the nervous apparatus.

B. *Functional Examination.*—Impairment of hearing, both for sharp sounds and speech, is either profound or the patient is absolutely deaf. If any power of audition remains, it is usually for the low notes of the scale, the higher notes not being heard at all. Rare exceptions are found where the apex of the cochlea is first involved. This, however, occurs but seldom; in fact, the lower notes of the scale may be heard with abnormal clearness during the stage of hyperæmia on account of the hyperæsthetic condition of the nerve. Bone conduction is greatly diminished, and after a few hours is absolutely lost. It may be completely absent, although the ear may still perceive sounds by aërial conduction.

Prognosis.—If the patient recovers from the meningeal inflammation the outlook for the preservation of hearing is exceedingly grave. In severe cases absolute deafness results, while in the milder instances a certain amount of audition may be preserved. The disappearance of the subjective noises is a rather unfavorable symptom, since it denotes complete anæsthesia of the auditory nerve or perceptive centres, and often absolute destruction of the terminal nerve filaments. The involvement of the labyrinth in no way affects the prognosis as regards life. This disease is of particular moment when met with in very early life, since the loss of the auditory perception renders the patient mute as well as deaf. This is true even if the child has learned to talk fairly well, such words as have been learned being forgotten. In older children mutism may not follow, since the association between written and spoken words is sufficient to preserve the power of speech. The effect of treatment is usually unsatisfactory in the severe cases, although in the less severe cases, where a certain amount of hearing has been preserved, the function of the organ may be still further improved.

Treatment.—But little can be done to prevent the extension of the meningeal inflammation to the labyrinth. With the development of the hyperacusis it is wise to apply cold locally to the mastoid process, while at the same time free bloodletting is advisable, provided the general condition of the patient will admit of this. Free catharsis should also be obtained if the general condition does not contraindicate it. If our efforts are unsuccessful, nothing can be done until the acute symptoms have subsided, after which the reduction of labyrinthine pressure by the use of pilocarpine, either administered hypodermically or by the mouth, is always advisable, and is frequently followed by favorable results. This is true, although the patient may not present for treatment until a considerable period after the attack of meningitis, and where a careful examination seems to indicate that even a small portion of the cochlea has escaped destruction, the utility of the organ can usually be improved. In addition to the pilocarpine, strychnine in large doses is an agent of considerable value in preventing a rapid degeneration of the nerve fibres in the trunk, from the changes which have taken place in the labyrinth. When the acute symptoms have completely subsided, exercise of the organ, either through the agency of the human voice—a conversation tube being used, if necessary—or by the employment of some instrument based upon the principle of the phonograph, may still further improve the hearing. It is to be specially remembered that both dynamic and therapeutic measures must be continued for a long period in order to be of the least value, and any slight gain is to be looked upon as encouraging. It is wise, in case pilocarpine is to be administered for a long period, to occasionally stop it altogether for an interval of one to three weeks, after which it is to be resumed, beginning with small doses. The general condition of the patient must always be kept as near normal as possible, and all conditions are to be avoided which disturb the labyrinthine circulation either directly or indirectly.

CHAPTER XLII.

INVOLVEMENT OF THE PERCEPTIVE MECHANISM IN ACUTE MENINGITIS.

Pathology.—Meningitis of the nonepidemic type may produce secondary changes in the labyrinth in the same manner as the epidemic form of the disease. A traumatic meningitis is usually localized, and consequently the labyrinthine involvement is unilateral as a rule. In addition to direct extension through the labyrinthine aqueducts, the function of audition may be interfered with either by direct pressure of the products of inflammation upon the auditory nerve trunk, or by the involvement of the nerve sheath itself in the process, or by a localized meningitis over the cortical auditory area. When the labyrinth is the seat of the lesion, the process differs from that met with in the epidemic variety of the disease, in that it is less extensive and seldom leads to the complete destruction of the parts within the bony capsule. Pressure upon the nerve trunk causes degeneration of the nerve fibres according to well-known physiological laws, but seldom causes a destruction of all the fibres of the trunk. A cortical lesion presents essentially the same characteristics in that the entire sensory area is seldom destroyed.

An idiopathic meningitis interferes with the auditory function in the same manner, the exact pathological process depending upon the location of the intracranial lesion.

Symptomatology.—The symptoms will vary according to the particular location of the meningeal inflammation. Where direct extension to the labyrinth occurs, subjective noises of varying intensity, moderate or severe vertigo, and a varying degree of impairment of hearing are present. The severity of each of these symptoms will depend upon the extent to which the labyrinth is invaded. Where the trunk of the nerve is attacked the same conditions are present, although here the auditory impairment is the prominent symptom, and is usually most pronounced for the middle notes of the scale, perception for high and low notes being fairly well preserved. In either case the impairment of function is unilateral, the opposite organ remaining perfectly healthy.

Meningitis over the convexity of the brain involving the cortical perceptive area interferes with the function of both ears, the defect being most marked upon the side opposite to the cortical area involved.

If the affection is labyrinthine there is but little tendency to an increase in the symptoms, but rather to a spontaneous retrogression. Where the nerve trunk or the cortical centres are the parts primarily involved, the symptoms increase or diminish according as the meningitis becomes more diffuse or yields to appropriate therapeutic agents. In traumatic cases the area affected may be so located as to cause an interference with equilibrium alone, the hearing remaining intact, while tinnitus is absent. Another symptom quite characteristic is the development of hyperacusis or dysacusis, this latter symptom corresponding to the familiar ocular disturbance, photophobia, so characteristic of meningeal inflammation.

Lesions involving the cortical areas, or the paths of communication within the brain itself, produce the quite characteristic symptom of word deafness; the sound is heard but is not interpreted, or, if interpreted, is recognized imperfectly or slowly. A somewhat similar condition presents when the trunk of the nerve is involved, on account of the interference with the middle portion of the musical scale. As this portion of the register is the one ordinarily employed in conversational speech, the power of interpreting language is somewhat perverted, especially when the conversation is general. Complete deafness for any particular word or combination of sounds does not exist, however, but simply impairment. Again, as we shall see, the complete functional examination of the case enables us to distinguish with considerable exactness between the two conditions. While a labyrinthine lesion in the early stages is characterized by distressing tinnitus, any inflammation of the meninges which causes either pressure upon the nerve or upon the cortical perceptive area does not, as a rule, present this characteristic. Where pressure is exerted upon the trunk of the nerve, atrophy takes place quite early; hence any noise which may have been present in the incipient stage may disappear; and the same is true where the lesion is cortical. The future progress of the case will depend upon the intracranial changes present. In traumatic meningitis the disappearance of the acute local lesion will either be followed by a rapid decrease in the symptoms if the products of the inflammation are absorbed, or the condition may remain permanent, there being no tendency to progression. This is true of those cases where either an epidural or cerebral abscess does not follow. If either of these conditions is present the symptoms increase as the localized collection of pus becomes augmented in volume.

Diagnosis.—Our diagnosis will depend upon the history either of a traumatism, or, in idiopathic cases, of symptoms characteristic of meningeal inflammation. Examination by means of the speculum will reveal the parts in a normal condition, or, in the case of injury to the head, there may be evidences of rupture of the membrana tympani; and it must be borne in mind that when these signs are present there is more difficulty in determining the actual condition of the perceptive apparatus on account of the tympanic complication. When no middle-ear lesion exists, a determination of the exact portion of the perceptive tract involved depends entirely upon the functional examination and upon the antecedent history.

Functional Examination.—Where the lesion is labyrinthine, the lower tone limit is usually normal, the upper tone limit much lowered, bone conduction very slight or absent, while the impairment of hearing for the conversational voice is relatively less than that for high-pitched sounds. If the lesion is so extensive as to cause impairment for the conversational voice, this is seldom of a moderate degree, but the deafness is almost absolute. Paracusis Willisii is absent. Artificial aids to hearing do not improve the auditory power, and the patient becomes greatly fatigued after attempting to exert the power of audition for any considerable period, the hearing becoming rapidly worse, and evidences of severe mental exertion manifest themselves. The reaction to the galvanic current reveals usually a condition of marked hyperæsthesia when the lesion is recent. In cases of long standing this condition may be replaced by one of torpidity. When the trunk of the nerve is pressed upon, the upper and lower tone limits vary but little from normal. The notes of the middle register are poorly heard, and bone conduction is either absent or diminished to a marked extent. In testing bone conduction in these cases several tuning forks of different pitch should be used, since the nerve may react perfectly to forks of one pitch while it does not respond to others. The electrical reaction shows a persistent hyperæsthetic condition, the degree of hyperæsthesia varying but little on succeeding days, and being replaced by one of torpidity in the late stages only.

When the cortical centre is implicated the presence of tone gaps is a characteristic symptom. The most certain evidence of involvement of the cortical area, however, is the appearance of word deafness. The patient hears isolated sounds, and even spoken words, but finds it impossible to repeat spoken words or to correctly interpret their meaning. Naturally the lesion is bilateral, although the impairment is more marked upon the side opposite the involved area. Bone conduction in these cases is diminished, but seldom absent on account of decussation of the fibres. The tone gaps may be present in any portion of the scale. The galvanic current may reveal hyperæsthesia or some other deviation from the normal standard, such as a reversal of the normal reaction formula, or a paradoxical reaction. This latter term is used to designate the condition in which stimulation of the organ of one side produces phenomena on the opposite side. The concomitant symptoms ordinarily are sufficiently marked to confirm the diagnosis in cases where cortical involvement is suspected.

Prognosis.—If we exclude meningitis due to abscess and intracranial tumors, the process is not progressive in cases where the lesion remains intracranial. In the same manner, although to a less degree, an extension to the labyrinth seldom presents this tendency, the process being limited to the immediate area first involved.

In rendering an opinion, therefore, we may confidently state that the hearing will improve rather than diminish as age advances.

Treatment.—In the acute stage our measures of treatment are confined to those directed toward meningeal inflammation. After the acute stage is past, if the lesion is labyrinthine, the administration of pilocarpine hastens the absorption of the effusion within the labyrinth, and causes a rapid improvement in function provided complete destruction has not taken place. From the well-known action of the iodide of potassium on recent inflammatory exudates it is well to combine this drug with the pilocarpine in moderate doses. Where the lesion is intracranial, the administration of iodide of potassium for a considerable period in moderate doses is probably the best means at our command. Coincident with this we may give strychnine in the form of the sulphate or nitrate, beginning with small doses and increasing the amount to the point of tolerance. It must be remembered that the administration of strychnine should not be begun until all acute symptoms have disappeared. In cases of intracranial involvement the careful and systematic use of some apparatus designed to moderately stimulate the auditory nerve by sonorous vibrations is of undoubted value. The particular device is of but little importance, and may vary from a simple conversation tube to a more complicated instrument. It is important that the stimulation of the nerve in this manner shall not be carried too far, as, where it is too prolonged, the function of the nerve is blunted rather than preserved.

CHAPTER XLIII.

THE EFFECT OF DISEASES OF THE GENERAL NERVOUS SYSTEM UPON THE PERCEPTIVE MECHANISM.

WE have already considered the result of the acute inflammatory conditions met with in the meninges, and there remains for discussion those affections which are characterized by degenerative changes in the various parts of the brain. These are cerebral congestion, apoplexy, cerebral embolism, endarteritis, cerebral tumors, disseminated sclerosis, and tabes dorsalis. From the location of the cortical auditory centres, and the fact that each auditory centre receives fibres from the labyrinth of either side, any cortical lesion must be bilateral and extensive to produce absolute deafness upon either side. The crossing of the auditory fibres takes place in the medulla in the region of the olivary bodies, and an intracranial lesion upon one side could only produce total deafness in one ear when situated between the foramen of exit of the auditory nerve and the corresponding olivary body. A tumor at the base of the skull might possibly produce this effect, but we find that neoplasms seldom occur in this region.

Investigation of cases of cerebral hæmorrhage and of embolism show that in comparatively few instances is the organ of hearing affected to a perceptible degree. Even if the centre upon one side is largely destroyed, its place is supplied by the corresponding area in the opposite cerebral hemisphere, and the impairment in function is but slight.

The symptom most characteristic of a cortical lesion is known as " word deafness." Here words are heard but not understood, the patient simply obtaining the general impression of sound without being able to interpret it. A subjective symptom characteristic of the cortical involvement is the presence of certain complex auditory impressions or hallucinations. The patient seems to hear voices, the conversation either being directed to him, or he may simply be the listener. Among musicians these hallucinations may assume the character of well-known musical selections performed by an orchestra. The sufferer is able to follow each instrument as it performs its special part, and is frequently tormented by the impression that one or more is slightly out of tune. The exact pathological condition in the cortex exerts but little influence upon the symptoms, and may be either congestive, hæmorrhagic, degenerative, sclerotic, or neoplastic. Transitory subjective disturbances of this character are probably due to either cerebral congestion or anæmia. The possibility of locating a pathological process within the brain itself depends upon the presence of associated nervous symptoms due to the coincident involvement of contiguous areas, while at the same time an examination of the ear reveals the conducting mechanism to be in nearly a normal condition.

In tabes dorsalis the changes which have been recognized consist in an extension of the sclerotic process to the auditory nerve itself, or to its centres. It is characteristic of all affections of the acoustic nerve trunk that the electric excitability is increased until degenerative changes are so far advanced that the function of the ear is entirely lost. A permanent hyperæsthesia of the nerve, therefore, is strongly indicative of intracranial disease if peripheral irritation can be excluded in the given case. The portion of the musical scale most affected is usually the middle notes of the register, the upper and lower tone limits being normal. Where the cortical areas are involved the same hyperæsthesia may be met with. As distinguished from a labyrinthine lesion, any change in labyrinthine pressure brought about by artificial means, such as inflation of the tympanum, will exert but little influence upon the perception of sound through the bones of the skull. In labyrinthine disease, the disturbance from labyrinthine pressure brought about in this way usually diminishes bone conduction. It is also to be remembered that until a high degree of atrophy has been reached bone conduction is preserved when the symptoms are due to an intracranial growth.*

In discussing the symptoms in the previous pages we have confined ourselves to the hypothesis that the intracranial process was confined to the cerebrum. When the cerebellum is involved, disturbance of equilibrium occurs, together with nausea, while there may be no impairment in the hearing. Changes in the trunk of the nerve may give rise to disturbances of equilibrium, as well as to subjective noises and impairment of hearing.

---

* Politzer, Diseases of the Ear, American edition, p. 587.

Practically the diagnosis in these cases depends more upon the associated symptoms characteristic of the general nervous affection than upon the aural manifestations. The absence of any evident condition within either the conducting mechanism or labyrinth which is capable of producing the symptoms, while at the same time the evidence of the general nervous affection is marked, is the chief aid to diagnosis.

Regarding medication but little can be said. The chief indications for treatment will be furnished by the general nervous disease. If the aural symptoms are pronounced, they should be treated according to the directions already given. For the subjective noises the bromides will usually be found most efficacious. If there are evidences of faulty nutrition of the nerve tissue, strychnine in large doses will often be of benefit in preventing the total loss of function. From the possibility of a specific taint large doses of the iodide of potassium should be given in any case if there is evidence of intracranial involvement.

SECTION VI.

COMPLICATING AURAL DISEASES.

COMPLICATING AURAL DISEASES.

CHAPTER XLIV.

AURAL AFFECTIONS COMPLICATING THE ACUTE INFECTIOUS DISEASES.

We have already considered the changes which may take place in the perceptive portion of the auditory mechanism from the acute infectious diseases. In addition to these, the conducting apparatus is a frequent site of pathological conditions from the same cause. In a majority of cases the acute infectious disease produces an inflammation of the middle ear when this organ of special sense is in any way involved. It may be stated, as a general rule, that the severity of the inflammation within the tympanum corresponds in degree to that of the exciting cause. Thus, in the milder exanthemata—such as measles, varicella, mild influenza, and in mumps—an affection of the middle ear is usually confined to the lower portion of the cavity, constituting either a tubal catarrh or an acute catarrhal otitis media. If rupture of the drum membrane takes place, the discharge is serous or sero-mucous in character, and only becomes purulent by infection from without. In the more severe infectious diseases—such as severe cases of rubeola, scarlatina, variola, typhus fever, and diphtheria—the infection is more virulent, and here the connective-tissue structures are the chief seat of involvement. In other words, the otitis media, which complicates the diseases just named, has its origin in the upper portion of the tympanic cavity, and constitutes in reality a cellulitis. This cellulitis follows the course typical of such a process in any portion of the body, and very quickly results in extensive tissue necrosis, the soft structures breaking down with the formation of pus, while after a comparatively short interval the contiguous bony structures become affected and rapidly disorganize. It is probable that in a given case the selection of the lower or upper portion of the tympanic cavity as the seat of process depends entirely upon the degree of infection rather than upon the selection of any particular region by various organisms, the lower portion being involved in the milder cases, while the upper part is attacked in the more severe forms of infectious disease. Bacteriological investigation goes to show that the germ characteristic of the particular disease is not so much the cause of the otitis media as are the bacteria of suppuration, and that the number of these last-named germs present depends entirely upon the degree of systemic infection.

It may seem that this line is rather sharply drawn, as many cases present in which at first it is almost impossible to reconcile clinical experience with this theory. A careful study of many cases has convinced me that where these anatomical boundaries are transgressed this departure is always marked by a corresponding change in the general symptoms of the patient. Thus in epidemic influenza of a mild type, or in a mild case of measles, we should expect the lower portion of the tympanum to be involved, the characteristic signs being a comparatively slight amount of pain in the ear, of short duration, and quickly followed by the effusion of serum or seromucus. Where the quantity of fluid is not sufficient to cause rupture of the membrana tympani the fluid may remain in the middle ear for a considerable length of time. During this period the temperature will remain moderately elevated, or may reach normal if the process is entirely quiescent. Suddenly the temperature rises rapidly, the patient exhibits considerable prostration, and the pain in the ear returns. An examination will now reveal that, in addition to the effusion already present in the lower portion of the tympanic cavity, there are unmistakable evidences of involvement of the vault. The fluid in the middle ear is a culture medium which favors the development of pathological bacteria, and if these are still present, invasion of the upper portion of the cavity may take place at any time. In the same manner those cases where the process at first seems confined to the upper portion of the cavity, but does not go on and rupture through Shrapnell's membrane, may remain quiescent for several days, the temperature becoming normal and the pain in the ear disappear, although the local manifestations, such as redness above the short process and above the anterior and posterior ligaments, still continues. A sudden rise of temperature, with pain in the affected organ, is accompanied by a bulging of the entire posterior quadrant, and a rapid extension of the redness to the region of the membrana vibrans. Here the products of inflammation have passed into the atrium, following the long process of the incus; and the involvement of the atrium is to be looked upon as a secondary infection, giving rise to distinct symptoms. It is scarcely necessary to call to mind the clinical importance of the facts already stated when we remember that any inflammation in the upper portion of the tympanic cavity always constitutes a disease of considerable gravity, and one which demands prompt measures for its relief, while an inflammation of the atrium is comparatively simple if we can confine it to this region. According, then, as our general disease is mild or severe, we may predict with considerable certainty a corresponding degree of aural involvement. The exact method of dealing with these conditions has already been sufficiently dilated upon.

CHAPTER XLV.

AURAL AFFECTIONS DEPENDENT UPON CHRONIC VISCERAL CONDITIONS.

In general, we may state that any changes within the viscera produce disturbances referable to the ear chiefly from their effect upon the general venous circulation. Where the venous flow through the larger viscera is obstructed, a damming back of the return current from the internal ear results, leading in time to a dilatation of the venous channels within the auditory apparatus. This is particularly true of the labyrinth, and, as already mentioned, constitutes a common cause of labyrinthine congestion. Within the middle ear or within the meatus corresponding changes may occur, as evidenced by an increased vascularity in the parts and a greater tortuosity of the minute veins.

NEPHRITIS.

In nephritis, the pathological conditions found in the organ of hearing depend both upon the obstruction to the general venous circulation and also upon that condition of the arteries so frequently met with, known as arterio-capillary fibrosis. As the result of these changes within the vessel walls, the tissues are poorly supplied with blood, the result being that the entire economy is in a condition below the normal standard of health. The quality of the blood circulating within the vessels is also impoverished, its fluid elements being relatively increased.

Within the tympanum these changes in the vessels and in the quality of the blood frequently result in a transudation of serum through the vessel walls, the lesion being similar to that of pleural effusion in nephritis. This condition should not be looked upon as an inflammation, although it is frequently called otitis media serosa. The process is entirely mechanical, and the fluid is the result of transudation, and not of an inflammation. The fluid within the cavity may be absorbed spontaneously, or may remain for an indefinite period. When the middle ear is in this condition it is more liable to become the seat of a mild catarrhal inflammation than under normal conditions. Coincident with the effusion there is usually a partial or complete stenosis of the Eustachian tube, due to passive congestion of the lining membrane, with a diminution of atmospheric pressure within the middle ear. This change favors the passage of fluid from the blood vessels into the tympanic cavity, and the process tends to effect permanent changes. From the weakness of the vessel walls rupture is not uncommon, and hæmorrhagic otitis media, or, more properly, hæmato-tympanum, is occasionally found. These hæmorrhages may also occur in the external auditory canal, or between the layers of the drum membrane itself. Similar changes may take place within the labyrinth, in one case causing an increase in labyrinthine pressure either by an augmentation in the quantity of perilymph or by actual hæmorrhage into the labyrinthine channels. In the latter instances the extravasation of blood may destroy the end organ of the auditory nerve over a given area, rendering it useless and incapable of performing its function. This will lead to absolute deafness to the particular sound which this portion of the cochlea perceived. Hæmorrhagic changes in the sheath of the auditory nerve may also complicate a chronic nephritis. The blood supply of the labyrinth is derived from several channels, and hence the occlusion of one of these efferent vessels might take place without seriously impairing the function of the part, the blood supply being maintained through the collateral circulation.

METASTASIS.

An extensive suppurative process in any portion of the body, such as an acute osteomyelitis or bony caries, or necrosis located in any region, may be the point of origin of infectious emboli. These are carried through the various circulatory channels, either into the middle ear or labyrinth, and their lodgment produces symptoms dependent upon the shutting off of the blood supply of the parts beyond, or by a localized secondary infectious process which they excite. It is not improbable that chronic suppuration within the accessory sinuses of the nasal cavity is responsible for many obscure aural symptoms met with in these cases. The entrance of an embolus into the blood current from one of the accessory sinuses, and its subsequent passage into the labyrinthine vessels, is the most plausible explanation of the cases of mild tinnitus and sudden impairment of hearing of moderate degree which are frequently met with. In ulcerative endocarditis, an infection either of the internal, middle, or external ear may take place in the same manner, from a detachment of the vegetations on the cardiac valves.

In acute pulmonary affections, particularly pneumonia, an acute middle-ear inflammation may result from the passage of the infectious germ through the blood current and its lodgment in the tympanic mucous membrane. It is probable that certain cases are due to the entrance of germs through the Eustachian tube. The degree to which the middle ear is involved will depend upon the severity of the pulmonary process; if this is severe, the aural inflammation will be suppurative, while in the milder cases it is a simple catarrhal inflammation, or may cease spontaneously at the stage of congestion.

TUBERCULOSIS.

In tuberculosis, the involvement of the middle ear is characterized by the insidious manner in which the infection develops, frequently the first symptom which the patient recognizes being discharge from the ear, there having been no pain or noticeable impairment of hearing previous to this time. On examination, the entire drum membrane may be wanting, and in some cases the ossicula themselves may have become involved. Where the destruction of the membrane has taken place over a limited area the perforation presents a somewhat characteristic appearance. It is usually circular, the edges are thick and everted, and present, instead of the bright-red color commonly observed in a simple perforation of the membrana tympani, a blue-white, glossy, œdematous appearance comparable to that seen over the arytænoid cartilages in laryngeal tuberculosis. Another condition which is somewhat characteristic is the appearance of two or more distinct perforations in the membrane. Where the ossicles are involved, the surrounding bony structures are quickly attacked, and the entire mastoid may be broken down even at a very early period. It is important to recognize the disease in its incipiency, as prompt removal of the affected parts may check the progress and relieve to a degree the systemic condition dependent upon it. Usually, when the organ of hearing is attacked, the pulmonary or visceral involvement is an affair of so much greater gravity than the aural affection as to make this latter insignificant. If, from the severity of the symptoms, or in the hope of stopping the progress of the affection it is deemed advisable to attack the local lesion, we should remember that any operative measures will be greatly aided by the administration of those drugs which seem to exert a specific influence upon the tubercular process.

The nutrition of the patient should be particularly attended to. Cod-liver oil, the hypophosphites, and the various preparations of malt are all of value in the various cases, and much is to be said in favor of the administration of creosote in doses of one half to three grains three or four times daily. While I do not wish it to be understood that the tympanic lesion demands treatment in a large majority of cases, or that radical treatment directed to this part is advisable, it is well to bear in mind the possibility of systemic infection from this focus, and also the fact that the local process is sure to extend rapidly, and is hence more easily checked in its early stage than after it has existed for a considerable period.

LEUCÆMIA.

In leucæmia a form of deafness is found depending upon the passage of minute cells or lymph corpuscles into the labyrinthine channels (Fig. 158), narrowing their calibre and in time even leading to a complete obliteration of their lumen. In the early stages this deposit is cellular in structure; but if the patient survives the disease for a long time, organization of this tissue may take place, and the obliteration of the labyrinthine passages is effected by an osseous deposit, the symptoms depending upon the extent of the local process and upon its severity. It is recognized by the presence of the general leucæmic condition, and with the sudden appearance of deafness which gradually grows worse, together with vertigo, nausea, and subjective noises. The functional examination reveals a lesion of sound-perceiving apparatus rather than one referable to those parts concerned in sound transmission. Practically nothing can be done to stay the progress of the affection, our efforts at treatment being as futile as those employed to combat the constitutional affection.

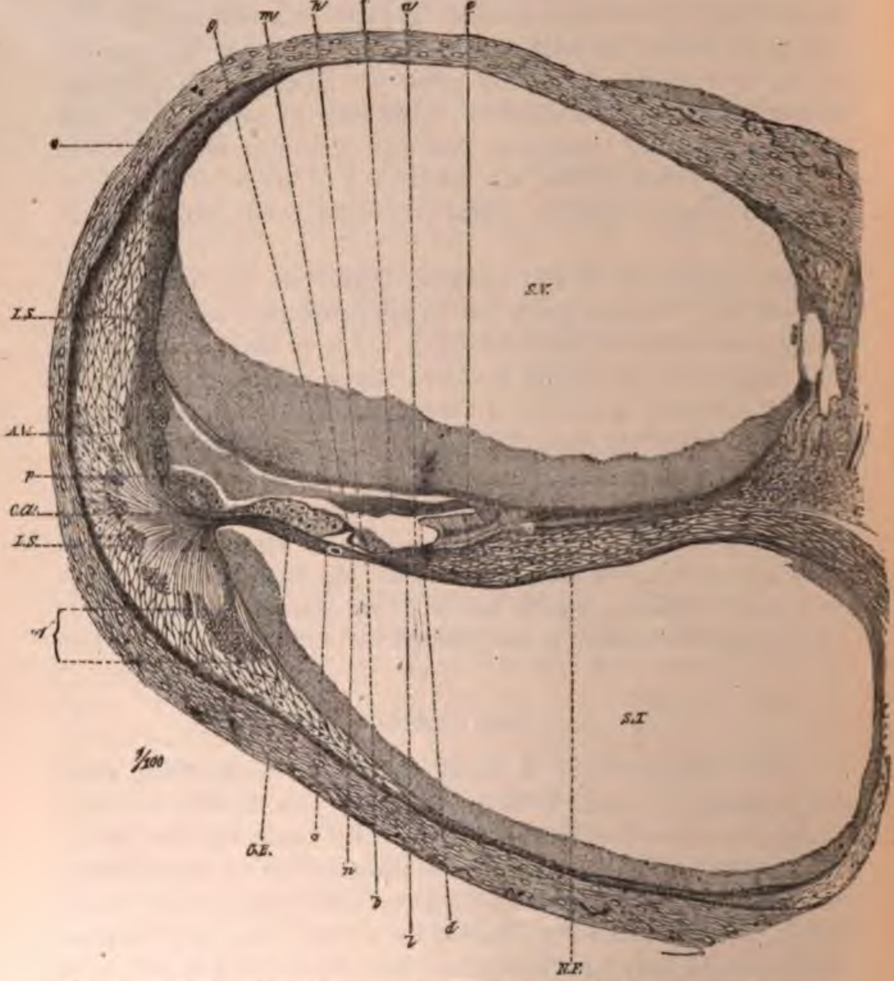


FIG. 171.—Section through the middle turn of the cochlea in a case of leucæmia, showing infiltration. (Gradenigo.*) *O*, Bone; *S. V.*, Scala vestibuli; *S. T.*, Scala tympani; *L. S.*, Ligamentum spiralis; *A. V.*, Stria vascularis; *N. F.*, Nerve expansion in the lamina spiralis; *e*, *f*, *g*, Membrana tectoria; *h*, Inner hair-cells; *m*, *n*, Corti's rods; *a*, *l*, *d*, Limbus lamina spiralis; *l*, Epithelium of sulcus spiralis internus; *p*, Epithelium of sulcus spiralis externus; *C. E.*, Outer cells of Corti and Deiter; *c*, *c*, *l*, Claudius's cells.

---

* Arch. für Ohrenheilk., vol. xxiii, p. 242.

DIABETES.

In severe cases of diabetes the most characteristic affection referable to the ear is the occurrence of acute circumscribed external otitis. When we remember how prone the diabetic patient is to furunculosis, we can explain the occurrence of the aural lesion upon the same ground. Eczema of the auricle and canal is also of common occurrence. Within the tympanum there is scarcely any condition characteristic of diabetes, although it is probable that all structures, including those of the middle ear, are more liable to attacks of inflammation than under normal conditions. Symptoms referable to the sound-perceiving apparatus probably depend upon either labyrinthine hæmorrhage or extravasation into the medullary or cortical centres. The repair of any lesion spontaneously is slow in these cases. When the condition is an acute inflammatory one, suppuration is the rule. This is worthy of note where the mastoid process becomes involved consecutive to an inflammation within the canal or middle ear. Often, in spite of the greatest precaution, prolonged suppuration occurs; and while we should not be deterred from operating upon diabetic patients for this reason, efforts to secure perfect asepsis must be vigorously enforced.

GOUT AND RHEUMATISM.

Gout and rheumatism probably exert a greater influence upon the organ of hearing than is usually supposed. It is not necessary that the patient shall have ever been the victim of an acute gouty or rheumatic attack, the hereditary diathetic condition being sufficient to induce pathological changes within the ear. While the cases dependent upon gout or rheumatism as the sole cause are probably rare, any acute or chronic inflammatory process arising from some other cause is modified to a marked degree through these diatheses. Thus in numerous cases of nonsuppurative otitis media our measures for relief may be without result until internal medication is directed toward the correction of the gouty or rheumatic taint. In the canal itself a persistent eczema rather mild in character is frequently met with in patients suffering from a gouty diathesis. Although in itself this inflammation would scarcely attract the attention of the patient, it leads to a condition of the cutaneous lining of the canal which favors the development of vegetable parasites. When these have once gained lodgment in the meatus, the local inflammation which they excite by their presence is sufficient to produce marked symptoms from which the patient seeks relief.

Treatment of the local condition will probably be without avail unless the gouty diathesis is at the same time borne in mind and combated. In the tympanum itself we find in rare instances an inflammation of the interossicular articulations which is probably rheumatic in nature. The local appearances are confined to the immediate region of the articulation. The pain is severe, the constitutional disturbance marked and out of proportion to the local lesion, and efforts to afford relief are unsuccessful until antirheumatic drugs are administered. The symptoms abate under this plan of medication, and the disease follows the course of an acute articular rheumatism of any of the larger joints. It was formerly supposed that the gouty diathesis exerted a peculiar influence upon the development of exostoses within the bony meatus, but this theory has not been borne out by subsequent investigation. Of much more importance is the influence which this diathetic condition exerts upon the walls of the blood vessels. Arterial degeneration takes place, the vessels becoming rigid through the deposit of lime salts in their walls, thus narrowing the calibre and so weakening the walls that they are easily ruptured by any sudden increase in blood pressure. These effects are most marked within the labyrinth, and give rise to subjective noises, giddiness, and slight impairment in hearing. In advanced cases the occurrence of capillary hæmorrhages also serves to explain many of the symptoms met with.

MEDICINAL SUBSTANCES.

The ingestion of certain medicinal substances exerts a specific influence upon the organ of hearing. Of these, the most prominent is quinine. Salicin, salicylic acid and its salts exert a similar influence in a less degree. In general these changes constitute in mild cases a congestion both of the middle ear and of the labyrinthine structures. When any drugs of this character are administered in excessive doses this hyperæmia may lead to rupture of the vessels, causing minute hæmorrhages. When administered for a long period, even in moderate doses, the chronic congestion produces structural changes particularly within the labyrinth, which do not disappear even after the administration of the drug is stopped. When the ear is in a normal condition it is probable that serious injury following the exhibition of these drugs is comparatively rare; but where the ear is the seat of a chronic inflammatory process, or is particularly susceptible to circulatory changes, their use is to be guarded against. It is manifestly impossible to prevent the use of these remedies in all cases of chronic aural disease, but they should never be given except in an extremity, and then should be exhibited in small doses, and discontinued as soon as possible. The habit of prescribing large doses of quinine for a cold in the head can not be too strongly prohibited.

The moderate use of tobacco influences the organ of hearing but slightly, whether the parts are in a state of health or disease. It was formerly supposed that its use aggravated any pre-existing catarrhal inflammation of the upper air tract, and in this way aggravated chronic affections of the tympanum. The danger in the use of tobacco does not lie in this direction, but rather in the effect which the drug exerts upon the general nervous system. If the habitual use of tobacco produces constitutional disturbances referable to the general nervous system, there is no question about the advisability of stopping it at once. That it should exert any specific action upon the organ of hearing, while the general nervous organism escapes, is exceedingly improbable. We may practically disregard any action upon the conducting mechanism; and if the receptive portion of the auditory system suffers from its habitual use, we shall have confirmatory evidence from its effect upon other portions of the nervous system. The particular region of the perceptive tract affected is probably either the nerve trunks or centres themselves.

CHAPTER XLVI.

DISTURBANCES OF AUDITION DEPENDENT UPON FUNCTIONAL NERVOUS DISORDERS.

THE most common functional disturbances of the nervous system which produce any marked effect upon the organ of hearing are those known under the terms "neurasthenia" and "hysteria."

Since the exact nature of these conditions is at present problematical, the manner in which they influence the various portions of the sound-perceiving mechanism is a matter of conjecture. In certain instances neurasthenic or hysterical patients will present marked disturbances referable to the organ of hearing. These disturbances probably depend upon some slight pre-existing pathological condition which ordinarily would pass unnoticed. The lesion may lie either in the meatus or in the tympanic cavity, and be entirely unrecognizable upon careful examination; but as it constitutes the point of least resistance in the nervous system, the manifestation of a neurasthenic or hysterical condition is exhibited here rather than in another locality. The reason for believing this, is that where a moderate affection of the sound-conducting mechanism exists, the disturbance of function is out of all proportion to the pathological condition present; and in addition to these symptoms, which are characteristic of involvement of the transmitting apparatus, certain other manifestations present which can only be explained by the abnormal general condition.

NEURASTHENIA.

In neurasthenia the entire nervous system seems to be overtaxed by even a moderate effort; and where the function of any one organ is impaired, as in the cases under consideration—the organ of hearing—this impairment is magnified to a great degree. In general these cases are characterized by the symptom which may be termed "auditory strain." In conversation with one individual the patient hears fairly well, and the hearing is usually better early in the morning. After being subjected to the fatigue consequent upon the day's activity, the hearing power becomes much diminished, and any effort on the part of the patient to disguise the symptom simply magnifies it. The local impairment, in turn, reacts upon the general condition of the patient to a considerable degree, frequently causing him to become hypochondriac, and in some cases leading to acute melancholia. The hearing is more impaired in a noisy than in a quiet room; tinnitus is present, and varies greatly in degree, being more marked when the patient is tired. In addition to these subjective symptoms, certain others manifest themselves, such as a feeling of formication in the canal; a feeling of occlusion in the meatus, as though a foreign body were present; or a sensation of irritation referred either to the Eustachian orifice or to the base of the tongue. Often during the process of examination the hearing fluctuates greatly. If patients can be convinced that no test is being made, they frequently respond to questions asked in a moderate tone of voice; as soon, however, as they become aware that the power of audition is being estimated their anxiety to hear causes a marked diminution in the power.

Diagnosis.—As said before, certain deviations from the normal standard may be found upon speculum examination, or these departures from the normal may be so slight as to be entirely overlooked. Functional examination is a matter of considerable difficulty, especially if any recognized lesion of the conducting apparatus is present, the answers of the patient being very misleading unless the general condition is borne in mind. As a rule, low tones are well heard, the lowest limit of the scale being frequently preserved, even where inspection shows a marked alteration in the conducting mechanism. The upper tone limit may be moderately lowered, but is occasionally elevated, and the high notes may be painful. Bone conduction is diminished, while sharp sounds, such as the tick of a watch or the click of the acoumeter, give varying results, being heard at one time exceedingly well, at another time poorly or not at all. The voice is usually heard better relatively than either the watch or acoumeter.

The most valuable aid in diagnosis is a comparison of the results obtained by functional examination with the general history of the case. When we consider the undue importance which these patients attach to the slight subjective symptoms of which they complain—referable to the meatus, the vault of the pharynx, or region of the Eustachian tube—we can readily understand why the results of functional examination should be so at variance with what might be expected.

The hyperacusis which is quite commonly observed in these cases explains the preservation of the lower tone limit even when this should be considerably elevated. We are apt to be misled also by this symptom, for quantitative tests may yield entirely negative results, the patient hearing the watch, acoumeter, or whispered speech at the normal distance. Continuing the examination for some time, we shall usually find that the organ soon becomes tired and the hearing power rapidly diminishes. This fatigue manifests itself not only for any one sound, but when this condition is reached all sounds are poorly perceived. This, we must remember, is a marked deviation from the normal standard. In health, although the sonorous vibrations of any given pitch will, after a time, so fatigue the perceptive centres as to reduce the power of audition for that particular sound, yet this impairment of function does not invariably occur with the perception of sounds of different pitch, but rather renders the hearing of them more acute. In order to test the ease with which the ear is fatigued it is only necessary to make use of a tuning fork of 512 V. S., or the octave above this, and maintain the fork in vibration close to the ear for a period of five to ten minutes, setting it in vibration anew as soon as its note becomes weak. If the fork is struck with approximately equal force each time, it will be found that the period during which its vibrations are perceived will become shorter and shorter. In some cases we find that the ear very quickly ceases to perceive the note of the fork. If now the instrument is removed from the ear for a few seconds, and then again brought immediately in front of the meatus, the note will again be heard, although the instrument has not been set in vibration afresh, and hence the sound is less intense than when it was removed from in front of the ear. This is called a secondary perception of the note. In marked instances we find even tertiary or quaternary perceptions. This phenomenon corroborates the statement of the patient that the power of audition is poorest in listening to general conversation.

Prognosis.—Aside from any organic changes which may be present either in the middle ear or labyrinth, the prognosis will depend upon our ability to control the general nervous condition. This is difficult, and the outcome of such a case must always be uncertain. If the patient can be persuaded to think less about his hearing, there is fair hope that the power of audition will improve.

Treatment.—No drugs exert a specific action upon the central portion of the auditory apparatus in this condition, and the treatment of defective hearing will resolve itself into the treatment of neurasthenia. Strychnine in large doses, as a nerve tonic, is of use in a considerable proportion of cases. Where the strychnine increases the excitability of the patient, this may be controlled by the administration of bromide of sodium in proper doses at the same time. We thus overcome the reflex excitability produced by the first drug, while we in no way diminish its action as a nerve tonic and as a stimulant to the nervous centres. A complete change of scene is advisable, and where the disease has resulted from prolonged mental exertion it is well to interdict work of this kind. This is by no means an absolute rule, as a considerable proportion of patients do not improve unless their minds are occupied in some manner. A complete change of occupation is desirable in these cases, since they may become so interested in their work as to forget themselves, and thus second our efforts in restoring their normal condition.

HYSTERIA.

This affection is closely allied to the one just described, and frequently accompanies it. Why, in a given case of hysteria, symptoms referable to the ear are paramount, can be explained only on the ground already given in considering the effects of neurasthenia—that in these cases the ear is the point of least resistance.

Symptomatology.—Impairment in hearing varies greatly in degree, but is usually profound, and the patient may be completely deaf. The deafness comes on suddenly, as a rule, quite frequently as the result of some severe mental shock, and possesses the peculiar characteristic of preserving the original degree of impairment throughout the entire history of the case. The condition neither improves gradually nor does it grow worse. Complete restoration of function may take place from no assignable cause, and may occur quite as suddenly as the power of hearing disappeared.

Another curious symptom is the so-called transference of the lesion from one side to the other. For a certain length of time the organ of one side alone will seem to be perfectly deaf. Suddenly the hearing will be restored upon this side, but at the same time the organ of the opposite side becomes affected. This change may be repeated any number of times. Pain is quite commonly complained of in the region of the ear, it being located either deep in the meatus or in the mastoid process. Occasionally this pain is referred to the pharyngeal vault, although this is not common. Giddiness and subjective noises are usually absent, the case thus presenting a marked contrast from one dependent upon neurasthenia. Where other symptoms of a hysterical nature are present, such as hemianæsthesia or hemiplegia, the defective ear is usually on the side of the body presenting the sensory or motor impairment, although this is not invariable.

Diagnosis.—The above phenomena may be observed where to all appearances the organ is perfectly healthy, or we may find, upon examination, evidences of a preceding suppurative or nonsuppurative process. The eye alone aids us very little in making a correct diagnosis. Much information, however, may be obtained by testing the sensitiveness of the meatus and drum membrane by means of the probe, the parts being quite frequently anæsthetic. Functional examination, also, may reveal nothing characteristic, although in quite a number of cases we find that both the upper and lower limits of the scale are poorly perceived, the lower tone limit being elevated, while interference with the upper tone limit seems to be more common than with the lower, the high notes being but poorly heard, as a rule. This reduction of the upper tone limit is distinct, usually extending as low as 4 or 6 of the Galton scale.

A symptom frequently met with in an examination is the alternating perception of the high notes first on one side and then on the other. Upon one side the upper tone limit will be found greatly reduced, while the organ of the opposite side will perceive the highest tones of the scale with ease. On repeating the experiment, the condition will be exactly reversed, and this alternation may be repeated several times during the examination.

The occurrence of other hysterical manifestations affords confirmatory evidence. This is particularly true if the field of vision is investigated, since in most cases this is uniformly contracted.

Prognosis.—It is absolutely impossible in a given case to render an intelligent opinion as to the recovery of the hearing. It is a well-known fact that in hysteria many of the symptoms may completely disappear, while the others remain unabated; and we also note that interference with any special sense is a symptom which does not disappear readily.

Treatment.—Those drugs administered for the control of hysteria are indicated in these cases. Valerian, either in the form of the simple tincture or the ammoniated tincture, is often of value. The same is true of asafœtida, the bromides, various preparations of zinc, phosphorus, hyoscyamus, galbanum, etc.

Hypnotic treatment is probably of more value in these cases than any other, and is always worthy of a trial. It should never be forgotten that hysteria is a disease, and that the patient is not malingering; hence severe measures are worse than useless. Curious instances have been reported of the complete disappearance of the deafness upon bringing a magnet close to the ear. By this same means it has also been possible to transfer the condition to the opposite side.

CHAPTER XLVII.

REFLEX AURAL DISTURBANCES.

A PATHOLOGICAL condition in any portion of the body may produce within the organ of hearing, not only alterations of function, but also certain visible changes. While we are familiar with the precise mechanism by which motor reflexes are brought about, those of a sensory or trophic character are as yet obscure. The most plausible view is, that under the reflex stimulus certain changes take place in the vascular supply of the part affected, through the action of the vasomotor nerves, and that capillary dilatation is responsible for the phenomena produced. In the conducting portion of the organ of hearing the deviations from the normal standard are of such a nature as to be visible to the eye, while in the nervous apparatus subjective symptoms are the only indication of any change from the standard of health. Changes which take place in the auricle from reflex action may cause an abnormal redness or congestion of the part; or, if the capillaries are constricted, the blood supply will be diminished, the ear appearing pale and bloodless. When the trophic nerves are interfered with, a cutaneous eruption may occur, the most common of which is herpes, the auricle being covered by small vesicles at first discrete, but by coalescence forming bullæ. The symptoms have already been described by herpes of the auricle.

Within the canal a circumscribed external otitis may depend upon a reflex cause, the pathological lesion producing it being most frequently a corresponding condition upon the opposite side. Hypersensitive areas may also develop in the meatus, usually in the bony portion and upon its floor, the region being excessively tender to the touch of the probe, while ocular inspection either reveals no deviation from the normal condition, or only a minute erosion at the tender point. In some instances periodical attacks of bleeding from the meatus occur, depending upon changes in some remote organ of the body.

Within the tympanum a reflex stimulus may cause a transudation either of blood or serum; in either case the quantity of fluid may be so great as to cause rupture of the membrana tympani. Instances of otitis media of a reflex character have also been observed. Pain in or about the ear in a vast majority of cases depends upon some local inflammatory process. It is occasionally met with where no inflammatory process presents upon the most careful examination. In children particularly, a reflex otalgia often occurs, depending either upon the eruption of the molars or upon early dental caries. This latter condition is occasionally the cause of an inflammatory affection of the middle ear, either acute or chronic. A symptom of rare occurrence is a periodical œdema over the mastoid process, accompanied by exquisite pain and tenderness. I have observed one instance of this in which acute middle-ear inflammation was complicated by this angioneurotic œdema; considerable difficulty was experienced in arriving at a correct diagnosis, and the question of the advisability of opening the mastoid was seriously debated. All reflex disturbances, particularly those of a painful character, are most frequently met with in females of a neurotic or hysterical type.

When we come to consider the perceptive tract, cases of anæsthesia or paræsthesia are by no means uncommon. A moderate impairment of hearing may be the result of visceral disturbances, particularly of the pelvic viscera, while tinnitus resulting from constipation, subacute gastritis, a pathological condition within the pelvis, etc., is of common occurrence. An interference with the statical function of the ear is probably the most familiar example of reflex excitation of the auditory perceptive apparatus. The giddiness so common in disorders of digestion is without doubt dependent upon stimuli conveyed to the auditory nucleus in the medulla through the vagus nerve, the vagus centre lying close to the nucleus of the vestibular nerve. It is probable that here the condition is one of increased vascularity from capillary dilatation. Reasoning in this manner, we are able to explain irregular attacks of impairment in the hearing of short duration, accompanied by intense subjective noises, by supposing that a similar disturbance has taken place either in the medullary centre of the cochlear nerve or in the cortical auditory centre itself. The symptom which leads us to suspect that any functional disturbance of the ear is dependent upon a reflex cause is the irregular appearance of the symptoms, and their sudden and complete subsidence, often from no apparent cause. Structural changes necessitate a certain permanency of the manifestation; and where this does not occur we can only explain the condition by supposing that the centres have been irritated by a temporary increase in the blood supply.

If now a thorough examination of the patient reveals a remote lesion, particularly if it is located in a region where organic changes are prone to excite reflex symptoms, we should bear in mind that such reflex symptoms may be quite as well referred to the organ of hearing as to any other portion of the body. We can not too strongly emphasize the necessity of a thorough physical examination in every obscure case; in other words, the otologist should locate subjective phenomena in the ear rather by exclusion than otherwise.

We have already spoken of those regions of the body where any specific change is particularly liable to exert a reflex influence upon either the centres of audition or the terminal apparatus of the auditory nerve. To this list we must add the opposite ear, since lesions of an inflammatory character, or injuries to the organ of one side, may produce not only temporary but often permanent changes in the opposite organ. The augmentation of the perceptive power observed when the opposite organ of hearing is subjected to sonorous vibrations has already been alluded to. Another familiar example is the effect of condensing the air in the auditory meatus, while at the same time a sounding body is held close to the opposite ear. If this experiment is tried, we find that the sudden condensation of air diminishes the perceptive power of the opposite organ. Here it is supposed that the path of the reflex current lies through the upper portion of the cervical cord, and the test is used to demonstrate the integrity of this portion of the central nervous system. The experiment is of much greater value from a clinical point of view in explaining the occurrence of subjective noises referred to one side, in which an examination of the ear reveals nothing abnormal. Examination of the opposite side frequently reveals either a narrowing of the Eustachian canal, the presence of impacted cerumen, or a marked pathological process within the tympanum, and the subjective symptoms do not disappear until the pathological condition in the opposite ear is removed.

Diagnosis.—The recognition of the reflex nature of these symptoms then depends upon their occurrence in an apparently healthy organ, and next upon the discovery of some remote pathological condition which may act as an exciting cause. A valuable confirmatory sign is that afforded by an examination with the galvanic current, a condition of marked hyperæsthesia usually being found. If we can exclude with certainty an active process within the middle ear or within the cranium itself, the auditory hyperæsthesia must be reflex; and if the cause does not lie in the opposite ear a remote lesion alone can explain it.

Prognosis.—Our ability to correct these reflex disturbances depends not only upon the amenability of the primary exciting cause to treatment, but also upon the duration of the affection before the patient comes under observation. The persistent excitation of the perceptive centres directly, or indirectly through the end organ of the nerve, may effect changes which will remain after the exciting cause has been removed. Where the case is observed early and depends upon a removable cause, the results of treatment are, as a rule, favorable.

Treatment.—Our first object when a case of this character presents for treatment is to relieve the aural symptoms from which the patient is suffering, without reference to the causation. Unless this cause is manifest, much valuable time is wasted in searching for the ætiological feature. The perceptive tract is in a state of constant hyperæsthesia, which from its long duration may be difficult to overcome after the exciting cause has disappeared. Undoubtedly the drug which exerts the most influence in these cases is bromide of sodium, or its equivalent, hydrobromic acid. By the administration of these remedies the receptive centres are rendered less sensitive to the action of stimuli. The effect is similar to that obtained when a broken limb or strained joint is placed in a fixation apparatus; the nervous tissues are put completely at rest, so to speak, by rendering them insensible to the action of the stimulus. Our next effort should be to discover the cause of the affection; this can only be done by a thorough investigation of the history of the case—not only the history of the disease, but one calculated to elicit all facts of medical or surgical interest throughout the entire course of the patient's life. An injury received in childhood and entirely forgotten may have set in play forces, which in adult years have produced the symptoms complained of. The age of the patient is to be borne in mind, particularly in the case of females, since the period about the menopause is a time at which these symptoms are particularly prone to make their appearance. The habit of life, the occupation, and all facts which may directly or indirectly exert an influence upon the nervous tone of the body, should be carefully investigated. Several factors may present as a possible cause of the aural disturbance, and time is necessary for the thorough elimination of the unimportant ones. It should always be borne in mind that these cases are among the most troublesome that we have to treat, and may for a long time be irresponsive to all our efforts. It is only by the process of exclusion that the exact ætiological feature can be discovered, after which its correction is usually a matter of comparative simplicity.

Diathetic conditions, particularly gout and rheumatism, may have manifested themselves previously in no other manner, and the symptoms referable to the organ of hearing may be the first intimation of the presence of such conditions. The history of heredity in such a case is the only clew to guide us to the discovery of the cause operative in the production of symptoms.

Where bromides fail to control the reflex phenomena, hyoscyamus, either in the form of the tincture or in the form of the alkaloid—hyoscyamine—may serve an efficient purpose. Under no circumstances should morphine be administered, since it is easy for the patient to acquire the opium habit if this practice is once begun. The various antispasmodics, such as asafœtida, valerian, galbanum, etc., are of use in certain cases, and indications for their administration are usually sufficiently clear. Where the symptoms have persisted for a long time and there are evidences of vascular dilatation, the fluid extract of ergot, in doses of fifteen to twenty minims, three times daily, exerts a beneficial action.

Symptoms of venous congestion dependent upon imperfect cardiac action demand the use of stimulants. Of these, strychnine is probably the best, provided no organic lesion is present. If the disturbance of circulation is only moderate, the use of a certain amount of an alcoholic stimulant daily is a valuable means of effecting the desired change. In asthenic cases, particularly where the patient has suffered from overwork, the addition of a moderate amount of wine to the dietary is followed frequently by happy results; the desired stimulating result is thus obtained without resorting to the administration of drugs. In cases where anæmia is coincident, naturally this condition must be treated on general medical principles; and the same is true of the management of those cases where there is a plethoric intracranial condition.

Symptomatology.—In very young children who have never spoken, the first symptom noted is usually the failure to acquire the power of articulate speech. Attention is then directed to the ears, and it is discovered that the auditory sense is also wanting. In older children, the failure to respond when spoken to and the gradual appearance of mutism declare the nature of the affection. In these older cases the hearing may not be entirely lost at first, and as the patient seems to hear loud sounds, parents often neglect the condition until it is too late to prevent deaf-mutism.

Diagnosis.—Since the age at which children acquire the power of articulate speech varies greatly, and as the same is true of the age at which the infant responds to stimulation of the organ of hearing, it is often difficult to determine whether or not a child is deaf or whether the development of the special sense is delayed simply. With a history of any previous intracranial disease or any evidence upon ocular inspection of an abnormity, congenital or acquired, of the organ of hearing there is naturally a strong suspicion that the conditions are interdependent. When the child has learned a few words and fails to advance, the diagnosis naturally presents no difficulties. It is certainly unsafe to give any other than a guarded prognosis in patients under eighteen months of age.

Even very young children should be carefully tested as to their ability to perceive sounds varying in intensity and pitch. Tuning forks of low and high pitch furnish a convenient means of determining the probable presence of even a slight amount of audition. The forks should be set in vibration and held first before the ear, the attention of the child being diverted from the movements of the examiner. If the fork is heard, the little patient will usually give evidence of the fact, either by turning toward the source of sound, or there will be a change in facial expression which will be easily recognizable. If there is any doubt, the experiment may be repeated and the fork be held near the ear without being set in vibration. In the same manner bone conduction should be tested, the vibrating fork, and the same instrument in a state of rest being brought alternately in contact with the head. The Galton whistle should also be employed, and even in young children it is sometimes possible to obtain the limits of audition with fair accuracy.

Clapping the hands behind the child's head, snapping the fingers, etc., are also tests which may be of use; but my own experience has been that the tuning fork and Galton whistle will furnish the desired information.

Prognosis.—This is necessarily grave. Politzer* considers that the prognosis is better in the congenital than in the acquired cases. Certainly in those of congenital origin an unfavorable opinion should not be given in very early life, as the special senses may develop later. In the cases which follow any affection in early infancy, the nature of the disease which produced the aural affection, the extent of the local process, and the length of time which has elapsed before the patient comes under observation, all influence the prognosis.

Treatment.—When the malady depends upon a known cause the indications for treatment will be clear. In all cases presenting a condition which could give rise to the profound impairment this should be removed. In young children the presence of adenoid vegetations should be determined, and if the drum-membranes are intact any mass of this kind should be removed. In the same manner the history of an attack of epidemic cerebro-spinal meningitis or of an affection which could induce a labyrinthine inflammation should be an indication for the use of the proper therapeutic measures. A thorough examination should always be made, but if no indications are found for any particular plan of treatment, the surgeon should remember that therapeutic measures are useless in many cases and that valuable time may be lost. If there is no indication for any one plan of treatment, the child should at once be placed in the hands of those who make the education of such patients a life study. It is rare in any case which comes under observation during childhood to find a complete absence of the auditory function, and by proper training this may be much improved. The best results are obtained by those methods which stimulate the portion of the perceptive tract which remains by the use of the human voice, the sound being conveyed to the ear through a proper instrument, and by education render it capable of supplying the place of the perfect organ of hearing. It is surprising how much can be gained if these children come under observation at an early period, and when we have decided that nothing can be done to relieve the condition it is our duty to urge their education in this manner.

---

* Diseases of the Ear, American edition, 1894, p. 706.

DISEASES OF THE NOSE AND NASO-PHARYNX.

It is necessary to consider, in connection with the ear, certain affections of the upper air passages which either have been operative in the production of the aural condition, or still exert a marked influence upon it. The principal affections under this head will be considered briefly, and more with reference to their treatment than to the special symptoms which they produce.

We may classify affections of the upper air passages which come under this head as hypertrophic and atrophic. The first condition interferes with the circulation within the tympanum and labyrinth, and also disturbs the equilibrium of the drum membrane and ossicles by interfering with the free ventilation of the tympanic cavity. Atrophic changes, on the other hand, are much less frequently operative in the production of aural symptoms. Occasionally they represent the results of a previous inflammatory condition which has caused the aural affection, but, at the time when the atrophic changes are observed, exert but little influence upon the condition of the ear. The slight effect which they produce is mechanical, and depends upon the efforts of the patient in relieving the mucous membrane of accumulations of inspissated secretion dependent upon its atrophied condition. All these movements of the pharynx affect the calibre of the Eustachian tube and interfere with the atmospheric pressure within the tympanum.

Anatomically we shall consider—

1. Diseases of the nasal cavity.
2. Diseases of the naso-pharynx.

Under diseases of the nasal passages we have belonging to the group characterized by the presence of newly formed tissue, hypertrophic rhinitis and deformities of the nasal septum. An atrophic condition of the mucous membrane lining the nasal cavity is more rare, and constitutes the disease known as atrophic rhinitis.

In the naso-pharynx the most common hypertrophic condition is that known as adenoid vegetations, or enlargement of the pharyngeal tonsil. Neoplasms will not be considered here, since the aural symptoms to which they give rise are always secondary to those referred to the region from which the growth springs. An atrophic condition of the naso-pharyngeal mucous membrane constitutes the lesion in so-called naso-pharyngeal catarrh.

CHAPTER XLIX.

HYPERTROPHIC RHINITIS.—DEFORMITIES OF THE NASAL SEPTUM.

HYPERTROPHIC RHINITIS.

THIS condition consists in a true hypertrophy of the elements which go to make up the turbinated bodies, and involves especially the inferior turbinated body. In addition to the new growth of connective tissue present, the venous sinuses inclosed between its meshes become tortuous, and increase in size and in number. As a result of these changes, the tissue covering the inferior turbinated bone is increased in volume, and in marked cases hangs loosely from its bony attachment, so as to obstruct the nostril to a considerable degree. When the venous channels are engorged with blood, this obstructing mass may attain such a size as to completely close the inferior meatus and prevent the passage of air. The condition probably depends most frequently, according to Bosworth, upon a deformity of the nasal septum, and is most marked upon the side which is least obstructed by the septal projection. Owing to the obstruction of one nostril, each act of inspiration rarefies the air in the opposite nasal chamber and favors dilatation of the veins imbedded in the turbinated tissue. Continued for a long time, permanent tissue changes take place, resulting in the chronic venous engorgement, and in the hypertrophic tissue changes above enumerated. Such a condition renders the patient extremely susceptible to variations in temperature, which result in the affection commonly known as "cold in the head." Repeated attacks of this character operate to increase the chronic condition which underlies it. Without either entering into an enumeration of the various reflex disturbances depending upon this nasal condition, or dwelling upon the various local symptoms which are caused, we may state that the most common symptom of which the sufferer complains is the inability to breathe through the nose, and of frequently repeated colds in the head. The effect of these attacks of nasal stenosis may influence the hearing to a marked degree. Patients almost invariably state that during such an attack the hearing is much less acute than when the nasal respiration is not interfered with, and that, as the attacks increase in frequency, complete restoration of the hearing does not take place as readily. The intervals during which the hearing is fairly good become shorter and shorter, until every fresh attack seems to leave the power of audition more impaired. While many of these symptoms depend upon interference both with the circulation within the tympanum and the Eustachian tube, and with the proper ventilation of the middle ear, it is certain that a large proportion of cases are met with in which a physical examination reveals the Eustachian tube patent throughout the entire attack, and in these cases we must conclude that the turgescence of the turbinated bodies interferes with the venous return current from the labyrinth, causing labyrinthine congestion. Functional examination of these patients seems to confirm this view, and it is therefore important to remember that the venous engorgement within the nasal passages is operative in the production of labyrinthine symptoms directly, as well as in exciting changes in the tympanic cavity.

This is undoubtedly the reason why, in many cases, subjective noises will be improved by treating the upper air passages, although upon functional examination the patients exhibit none of the phenomena characteristic of an involvement of the conducting mechanism. The symptoms are, without doubt, due to vascular changes within the labyrinth dependent upon the turgescence of the turbinated tissue within the nasal cavity, and a removal of the cause relieves the symptoms. This fact certainly broadens the field of usefulness of intranasal surgery, which has quite commonly been supposed to be of value only in affections of the middle ear. Symptoms referable to the nasal passages themselves have already been alluded to, while a more detailed account of the various aural symptoms will be found under the different diseases before described.

Concerning the diagnosis of the condition, an examination both by anterior and posterior rhinoscopy will render its recognition easy. Upon anterior rhinoscopic examination, the inferior turbinated body will be seen to project into the passage, occluding it more or less completely and preventing an inspection of the posterior wall of the pharyngeal vault through the anterior nares. Where a deformity of the septum is present, the hypertrophy will be found more marked upon the side opposite to that occluded by the septal obstruction. Curiously enough, the patient will complain of this nostril as the one obstructed, the reason being that respiration through the opposite passage having been imperfect for a long time, he has ceased to observe changes in its patency, while the obstruction upon the opposite side, or the one upon which he depends for nasal respiration, is immediately recognized, as any increased turgescence practically renders nasal respiration impossible. Impact with a probe temporarily expresses the blood from the swollen turbinated tissue, the engorged condition immediately recurring as soon as mechanical pressure is removed. This examination with a probe also reveals to the operator that the membrane is thickened; it feels velvety to the touch as the probe presses it against the outer bony wall of the nasal cavity. Posterior rhinoscopy will reveal a similar condition over the posterior extremity of the lower turbinated body, and in some instances the hypertrophic changes may be more marked here than anteriorly. The posterior extremity of the inferior turbinated body may project into the cavity of the naso-pharynx as a round mass, completely occluding the choana of the affected side. Occasionally, instead of presenting a smooth contour, the surface of the mass is irregularly mammillated. This constitutes the so-called posterior hypertrophy, and may be present upon both sides.

The middle turbinated body may present evidences of hypertrophy, but less extensive usually than those exhibited by the inferior.

If a ten-per-cent solution of cocaine is sprayed into the anterior nares, and the parts again examined after a few minutes, a marked change will be observed. Owing to the action of the drug, the venous engorgement will have disappeared, the mucous membrane will be seen to apply itself more closely to the bony parts beneath, and the passage will be correspondingly more patent. The posterior pharyngeal wall will be readily seen in most instances, if the head of the patient is held in such a position that the floor of the nasal cavity is horizontal. In order to render this inspection of the posterior wall possible, the tip of the nose must be tilted up strongly, and the operator must so direct the rays of light that the deepest portion of the passage will be thoroughly illuminated. The light reflex of the posterior pharyngeal wall will then be seen, its recognition being more easy if the patient is asked to pronounce the letter *k*, thus elevating the soft palate. During this act the levator palati muscle will be seen to pass across the field of vision, encroaching upon the posterior nasal orifice.

The results of treatment of this condition are exceedingly satisfactory, and it will be always possible not only to relieve the attacks of intermittent turgescence of the mucous membrane, but also to cause the absorption of hyperplastic tissue and to return the membrane to its normal condition. Our efforts at treatment must be directed both to the results of the hyperplastic process and toward the removal of those causes which operate to produce the intermittent turgescence of the membrane.

If there is an obstruction upon one side due to a deformity of the nasal septum, this must first receive attention. The particular manner in which this shall be done will depend upon the choice of the individual operator, and somewhat upon the character of the obstruction. Where a prominent ridge is present this is best removed by means of the nasal saw. Where the septal obstruction is not sufficiently circumscribed to admit of removal in this manner, it may be burned away by means of the galvano-cautery. Some prefer the use of the electric trephine, and good results undoubtedly follow the use of this instrument, but the author has had no personal experience with it. For the relief of the turbinate hypertrophy the membrane should first be exsanguinated by means of cocaine, after which a small bead of chromic acid melted upon the tip of a metal probe should be applied to a limited area over the inferior turbinated body. The site of the application should correspond to that which was most prominent before cocaine was applied. The superficial extent of this application will depend upon the degree of the previous turgescence; usually the membrane is covered with the chromic acid over an area about the size of a split pea. Care should be taken to dry the nasal mucous membrane with a pledget of cotton before applying the chromic acid; any excess of acid is to be immediately removed by means of a dry pledget of cotton, to prevent its spreading over the surface of the membrane. The result of this application is to form an inelastic eschar, which prevents the swelling of the turbinated tissue after the effect of the cocaine has passed away. The blood vessels are thus supported, and their walls resume their normal tone. The slough separates at the end of from five to ten days, after which the operation is repeated over another portion of the turbinated body. These applications are continued until the patency of the passage has been restored. When the hypertrophy is excessive the cold wire snare may be used to remove redundant portions. The membrane is first anæsthetized with cocaine and the loop made to surround the mass. The wire is then drawn into the tube and cuts through the tissue which it surrounds. When the mass is situated in the posterior nares the wire loop should be made to cut through slowly by using the screw. In this manner hæmorrhage is avoided. As cocaine exsanguinates the membrane, it is well to use only a sufficient quantity to produce anæsthesia, in order that the snare may remove as much of the swollen mucous membrane as possible. After the operation is completed a little iodol is to be insufflated upon the cut surface, and the patient directed to avoid forcible efforts at clearing the nostril for at least twelve hours. In this way hæmorrhage is avoided, and prompt recovery is the rule.

Hygienic rules, such as proper attention to underwear, the daily use of the cold bath, etc., must not be forgotten in the treatment of these cases.

DEFORMITIES OF THE NASAL SEPTUM.

As the condition which obstructive lesions of this character produce have been discussed sufficiently under hypertrophic rhinitis, we shall consider here only the surgical procedures adopted for the relief of the obstruction. Where the deformity consists of a prominent ridge extending from the anterior portion of the cavity for a considerable distance toward the posterior nares, the nasal saw devised by Bosworth seems to be the most simple instrument for relieving the condition. The patency of the passage is to be restored by sawing off the obstructing ledge either from above downward or from below upward, according to the special topography of the lesion and the choice of the operator. This procedure can be carried out under cocaine anæsthesia, and is absolutely painless. Care should be taken that all instruments used at the operation have been previously sterilized by boiling in a one-per-cent carbonate-of-soda solution. After the operation, a little iodol is insufflated into the passage, so as to cover the exposed surface, and recovery is usually uneventful.

Where the obstruction is of such a shape that the saw can not be used the galvano-cautery may be employed. After local anæsthesia has been induced by the use of cocaine, the flat platinum blade should be applied to the most prominent point and the obstruction burned away. The platinum tip should be at a bright-red heat, as a temperature below this causes pain, while if it is heated to a higher degree the operation is likely to be followed by hæmorrhage. It is usually unwise to attempt the destruction of a large obstructing mass at one sitting. A portion of the obstruction should be burned away, and the operation repeated at intervals of ten days or two weeks until a patent passage is obtained. The wounded surface is dressed in the same manner as when the saw is used.

In many cases of nasal obstruction, due to septal deformity, the patency of the nasal passages is best restored by performing a submucous resection of the septum. This operation is applicable to many cases which were formerly operated upon either by means of the saw or the galvano-cautery. The operation, in many of these cases, is an ideal one. For a detailed account of the operation, the reader is advised to consult any of the recent works on Diseases of the Nose.

CHAPTER L.

ATROPHIC RHINITIS.

WHEN the nasal passages are the seat of an atrophic process the mucous membrane covering the walls of the cavity becomes attenuated and applies itself closely to the underlying bony structures. Microscopical examination teaches us that this atrophy affects the glands with which the membrane is supplied. The secretion is altered in character, and contains an excess of solid elements. The result is that it dries within the passage forming large irregular crusts upon the mucous membrane. As these crusts become dry they shrink, expelling the blood from the underlying mucosa, and mechanically augment the atrophic changes. Bosworth is undoubtedly correct in the statement that the disease is of long duration and develops as the result of purulent rhinitis in childhood, usually after one of the exanthemata. An examination shows an abnormal patency of the nasal passages, the membrane applying itself so closely to the bony framework that the turbinated bodies appear merely as lines upon the outer walls of the chambers. The post-pharyngeal wall can be easily recognized upon anterior rhinoscopic examination. Owing to the absence of the normal turbinated tissue, the air which reaches the vault of the pharynx through the nasal cavity is not properly moistened and abstracts moisture from the membrane in this region; the result is that we usually find a mass of inspissated mucus lining the vault of the pharynx. The patient complains not only of the crusts which are expelled from the nasal cavity, but also of the formation of a broad scale of tenacious mucus which is drawn down from the vault of the pharynx after repeated efforts at clearing the passage. These masses of inspissated secretion within the nasal chambers undergo decomposition and impart to the breath an extremely fetid odor, which is a characteristic feature of the affection.

The aural symptoms which are present in these cases are ordinarily insignificant, and are usually due to a previous involvement of the middle ear in childhood, when the purulent rhinitis was at its height. It is possible that the imperfect moistening of the air may play a part in the production of certain aural symptoms, although this has never seemed to me probable. It is more likely that the condition within the middle ear is concomitant with rather than secondary to the nasal condition.

The treatment of this affection is unsatisfactory as far as effecting a permanent cure, but efficient in relieving the patient from the disagreeable symptoms which it causes. The first measure is to thoroughly cleanse the nasal cavity, removing all decomposing crusts. This is best done by the use of the nasal douche. At least a quart of a weak saline solution, as hot as can be borne, is to be passed through the nasal chambers twice daily; this not only washes away decomposing masses, but exercises a certain stimulating action upon the membranes. During the day the nasal chambers may be cleansed at frequent intervals with an alkaline spray such as the following:

℞ Sod. bicarb.	gr. xx;
Acid. boric	ʒ ss.;
Acid. carbolic	♏. iv;
Glycerin	℥ j;
Aqua	q. s. ad ℥ viij.

M. Sig.: Dilute with an equal volume of water, and use in an atomizer as a nasal spray.

Later, irrigation may be employed but once daily. If faithfully continued, this treatment will prevent the discomfort attendant upon the nasal affection. The use of the nasal douche in these cases seldom produces aural symptoms, as the nasal passages are free and there is but little danger of the fluid entering the tympanum. It should always be remembered in employing the douche that the current should enter by the occluded nostril if there is any difference in the patency of the two sides. In this way it is practically impossible for any accident to happen. The relief of the nasal condition exerts but little influence upon the aural disease. The chief source of relief is probably due to the fact that the patient makes less vigorous efforts at expelling the crusts by blowing the nose, and the sudden increase of tympanic pressure is thus avoided. In some instances it is wise to further stimulate the parts by the insufflation of the following powder immediately after the douche has been used:

℞ Pulv. sanguinariæ............... ʒ ss.;
Pulv. lycopodii.................. q. s. ad ℥ j.

This causes considerable pain when insufflated into the nasal chambers and produces a profuse watery discharge. In this manner the turbinated tissues are stimulated to activity and return to a more nearly normal condition. The insufflation of the powder is to be discontinued after the tendency to crust formation has been checked.

Quite a large proportion of cases of so-called atrophic rhinitis will be found to be dependent upon suppuration, either in the ethmoid or sphenoid cells. Where such a suppuration exists, the condition will only be relieved by proper attention to the ethmoid or sphenoid suppuration. A detailed description of the methods of treatment will be found in the many works devoted to the special consideration of this subject.

CHAPTER LI.

ADENOID VEGETATIONS.

THIS condition is undoubtedly responsible for more than half of the pathological lesions met with in the tympanum. It is essentially a disease of childhood, probably a manifestation of a constitutional diathesis not inappropriately termed by Bosworth "lymphatism." The manner in which a mass of lymphatic tissue in the pharyngeal vault influences the organ of hearing has already been described in the beginning of this section, and need not be repeated. We should bear in mind that its influence is not alone confined to the middle ear, but that the vessels of the labyrinth undoubtedly suffer when this lymphatic tissue is the seat of repeated attacks of acute inflammation.

The symptoms dependent upon the presence of the growth are those of nasal obstruction, the sufferer breathing almost entirely through the mouth, especially during sleep. The nasal quality of the voice is wanting, and among young children there is a persistent discharge from the anterior nares. Such a growth becomes easily congested, and the cases present with the history of frequent colds in the head. A cold in the head in a child under twelve years of age is almost invariably dependent upon adenoid vegetations within the pharyngeal vault.

The aural symptoms are quite as characteristic as those referable to the air passages. There are frequent attacks of earache, terminating in some cases in a discharge from the ear, which may continue as a purulent otitis media; or where the inflammation is less severe there may be repeated attacks of tubo-tympanic congestion or of acute catarrhal otitis media without rupture of the drum membrane. In some instances the membrane is the seat of a minute rupture, and there is the history of slight serous discharge immediately following the attack, but disappearing spontaneously at the end of a few days.

The disturbances of function are also intermittent in character. With every cold in the head the hearing becomes dull, and, if the patient is old enough to explain the symptoms, he complains of a full or stuffy feeling in the ears, in addition to the impaired hearing. Many times this last symptom is misinterpreted in young subjects, and the child is considered inattentive. Such a history should always lead to a careful examination of the ears, as most children who seem to be "absent-minded" are really hard of hearing.

An examination of the oro-pharynx frequently shows that the faucial tonsils are enlarged, although they may be normal in size. Enlarged lymphatic nodules are frequently seen irregularly distributed upon the posterior pharyngeal wall, and are most numerous in the region of the posterior folds. Upon posterior rhinoscopy, the vault of the pharynx is seen to be occupied by a mass attached either to the roof or springing from the posterior wall. This mass may be most prominent in the median line, or the membrane covering the pharyngeal vault may be uniformly thickened, excepting in the region about the Eustachian orifices, where it is thrown into numerous folds and reduplications. The membrane covering the entire naso-pharyngeal space appears velvety and soft, resembling somewhat the faucial tonsils in appearance, although the tissue appears less firm. Where posterior rhinoscopy can not be conducted satisfactorily, such a growth may be seen by anterior rhinoscopy if the turbinated bodies have been previously exsanguinated by the application of a solution of either cocaine or adrenalin. When this method is employed, the patient should sit so that the floor of the nasal chambers is very nearly in the horizontal plane. If the light is directed into the cavity, the adenoid growth will be seen lying behind the posterior nasal opening, and sometimes encroaching upon it, if it springs from the roof of the naso-pharynx. When attached to the posterior wall, it is recognized by the undue prominence of this region, while manipulation with a probe demonstrates its papillary character.

In very young children either of these methods of examination may be impossible. In such a case the mouth should be held open either with a mouth gag or by means of a cork inserted between the teeth, and the surgeon should pass the index finger behind the palate into the naso-pharynx; the presence of the adenoid vegetations will be recognized by the soft, velvety feeling of the membrane. Upon withdrawing the finger it will be usually found covered with blood, as in young children the soft tissue is easily wounded.

The removal of such a mass is the only treatment to be considered if aural symptoms are present. The author's preference is the performance of a complete operation under general anæsthesia, the growth being removed by the forceps and curette.

All instruments are to be sterilized by boiling. The child is placed upon the table in a recumbent position. For children under twelve years of age chloroform is without doubt the best anæsthetic to employ. After complete anæsthesia the head is thrown backward over the edge of the table, or the same end can be attained by placing a small, hard pillow under the neck. By this procedure the vault of the pharynx is made to occupy a lower level than the larynx, and the danger of the accidental entrance of blood into the trachea is reduced to a minimum. The jaws are held apart by a properly constructed mouth gag, and the surgeon, standing upon the right of the patient, introduces the left forefinger behind the palate, where it remains until the operation is completed. The closed forceps held in the right hand is now passed along the left forefinger as a guide into the naso-pharynx, where it is opened and made to grasp as much of the growth as possible, the manipulation being directed by the left index finger. In this way the growth is removed piecemeal, and the operation is not considered complete until the examining finger fails to discover any masses projecting into the naso-pharyngeal space. The operation is completed by passing the curette into the space and sweeping it along each lateral wall and along the posterior wall of the cavity. The child is then turned over on the face, to facilitate the discharge of blood which has accumulated in the naso-pharynx during the progress of the operation, the mouth gag not being removed until this position has been assumed. No after-treatment is necessary, and, if the instruments have been sterilized, recovery is uneventful. In rare cases the operation is followed by an acute congestion within the tympanum or by a catarrhal inflammation. This accident happens so seldom that it can be practically disregarded. Another complication which is perhaps more frequent is an acute follicular tonsillitis, but this is also very rare.

Intimately associated with enlargement of the pharyngeal tonsil is a similar condition affecting the lymphatic tissue of the oro-pharynx. Many years ago the removal of enlarged faucial tonsils for the relief of impaired hearing was advocated by Yearsley. After Meyer had shown the marked effect which hypertrophy of the pharyngeal tonsil exerted in the causation of inflammatory processes within the tympanum, removal of the faucial tonsils for these conditions fell into disuse. It is probable that excision of the faucial tonsils is demanded in many cases of aural disease both of the suppurative and of the nonsuppurative variety. It is also probable that the beneficial effect produced is due largely to the absorption of the pharyngeal tonsil which follows the operation in many cases. As a rule, however, whenever the faucial tonsils are hypertrophied, and at the same time an inflammatory process is present within the tympanum, their removal should be advocated. In the large majority of cases enlarged faucial tonsils occur coincidently with an enlarged pharyngeal tonsil, and should be removed at the same time that the operation is performed upon the adenoid vegetations.

In young subjects, a fairly perfect tonsillotomy may often be done by the use of the tonsillotome. The author, however, prefers in every case to enucleate enlarged tonsils as thoroughly as possible, by first dissecting the tonsil out from between the pillars of the fauces, either by some form of tonsil dissector or preferably with the index finger. After the tonsil has been freed from adhesions in this manner, it may be removed either with a tonsillotome, or, better still, with a cold wire snare. In patients over twelve years of age, the snare should invariably be used in order to avoid hæmorrhage.

When tonsillotomy and the removal of adenoid vegetations are practiced at the same operation, it is usually wise to remove the faucial tonsils first, as the hæmorrhage from the pharyngeal vault rather obscures the field of operation if the adenoid growth is first attacked.

CHAPTER LII.

NASO-PHARYNGEAL CATARRH.

THIS condition is probably due to atrophic changes which take place in the pharyngeal tonsil in adult life. These changes consist in the disappearance of the cellular elements of the lymphatic nodules, and an increase in the fibrous tissue constituting the framework of the gland. It is probable that if the complete history of every case could be obtained we should find that these patients suffered from symptoms referable to a moderate hypertrophy of the pharyngeal tonsil during childhood. The condition, however, was not sufficiently marked to demand surgical interference, and in early adult life the symptoms disappeared. It is only late in life, when sclerotic changes take place, that symptoms dependent upon the presence of this tissue again appear. The prominent symptom of which these patients complain is the accumulation of viscid secretion in the pharyngeal vault. This secretion excites repeated efforts upon the part of the patient to draw the mass back into the mouth and expel it in this way. The annoyance which the condition occasions varies greatly in different individuals. In some, the effort to expel the inspissated mucus may bring on an attack of retching, or even vomiting, while in other instances spasmodic attacks of coughing may be excited. All manifestations due to the presence of the mass are exaggerated when the patient suffers from a cold in the head, and each fresh attack of inflammation renders the victim more liable to a succeeding attack upon slight exposure.

The aural symptoms in general are those enumerated in the chapter upon Chronic Catarrhal Otitis Media. We may find either a hyperplastic or a hypertrophic process within the middle ear. It is a question to what extent the naso-pharyngeal condition has been productive of the aural lesion. My own belief is that the two processes are coexistent rather than interdependent, and that the middle-ear changes have resulted from the presence of an excessive amount of adenoid tissue in the pharyngeal vault at an early period of life, and do not depend upon the sclerotic changes which have subsequently taken place in this tissue, although they are similar in character. Naturally the aural symptoms are aggravated by the congestion of the naso-pharyngeal mucous membrane, on account of the intimate relation which exists between the vessels in the two regions; but it is unwarrantable to assume that any treatment directed toward a correction of the naso-pharyngeal lesion will do more than exempt the organ of hearing from repeated attacks of congestion. The sclerotic changes have advanced to such an extent in these cases that we can not hope for an absorption of the new tissue, even if the parts are kept in a state of perfect equilibrium. Efforts at treatment will cut short an attack of inflammation in this region and relieve the throat symptoms, and will at the same time relieve the acute aural symptoms and cause the tympanic mucous membrane to return to the condition present before the acute attack. Beyond this, however, no treatment of the naso-pharynx will be of avail in adult life.

The treatment of the condition consists in local applications of an astringent solution to the naso-pharyngeal mucous membrane. These applications may be made by means of a curved applicator carried behind the soft palate, or, as I prefer, by a cotton-tipped probe carried through the anterior nares, the nasal mucous membrane having been previously anæsthetized with cocaine. The strength of the application should vary with the intensity of the inflammation. In the early stages a solution of nitrate of silver, thirty grains to the ounce, thoroughly applied to the naso-pharynx, may stop the progress of the attack completely. In the later stages a weaker solution should be employed. For the chronic condition relief is obtained by cleansing the naso-pharyngeal mucous membrane either by the post-nasal syringe or by means of a spray through the anterior nares; after which the application of a solution of nitrate of silver, of a strength of from ten to fifteen grains to the ounce, applied in the manner already described, will frequently be of service in relieving the discomfort attendant upon the condition.

CHAPTER LIII.

ARTIFICIAL AIDS TO HEARING.

In certain cases of impaired hearing of long standing, local treatment must be entirely futile. The impairment of function is so great as to render the improvement at the hands of the otologist absolutely impossible. These cases are found chiefly among individuals in advanced life where senile changes have taken place, both in the middle ear and in the perceptive mechanism. It is necessary, therefore, for the patient to call to his aid some device which will collect a larger volume of sound waves in order that the transmitting mechanism may be set in vibration, and thus permit of a more perfect perception of sound.

While the number of instruments which have been devised for this purpose is numerous, all depend essentially upon the simple principle of collecting a larger number of sound vibrations for transmission to the deeper parts. The simplest instrument, and the one which embodies the principle of all others, is the ordinary ear-trumpet. This is essentially a funnel, the smaller end of which is placed in the ear, while the broad end is turned toward the source of sound. In this way the sound waves are collected and reflected into the meatus, where they impinge upon the transmitting mechanism and are conducted to the deeper parts. Many modifications of this simple instrument have been made. Instead of a simple funnel, the sound-collecter has been changed in form so as to fit closely to the surface of the skull behind the ear, the sound-collector terminating in a small tube which fits into the external auditory meatus. While an appliance of this kind is sometimes of use to the patient, its appearance attracts attention, and it offers practically no advantage over the more simple ear-trumpet.

Of the ear-trumpets in use, perhaps the best is the small London hearing horn, the receiver of which is a bell-shaped shell of some light metal. From the side of this shell a small tube projects which is bent at right angles to the axis of the bell and is fitted with an ear tip for insertion into the external auditory meatus. The instrument is quite easily held in the hollow of the hand, and by placing the hand holding the instrument to the ear, with the ear tip in position in the canal, a considerably increased volume of sound is received. Up to the present time all attempts to magnify sound, so to speak, by means of some device which could be inserted into the external auditory canal, which would be practically invisible, have met with no success. The principle of the ear-trumpet already described in the above devices, has been applied to various articles of common use; for instance, the handle of an ordinary walking-stick may be fashioned into the form of an ear-trumpet, so as to collect the sonorous vibrations by simply holding the cane in the hand so that the ear tip is inserted into the canal and an increased number of sound waves thus collected and transmitted.

In another device the collecting cone is somewhat flattened and its external surface corrugated, so as to represent roughly a fan, the handle of the fan containing the tube for insertion into the ear; the fan being held in the hand, the ear tip is placed in the canal and the instrument effects its purpose.

A rather clever device has been invented by Vallerie, in which the hearing horn takes the form of the handle of a lorgnette. This instrument perhaps attracts less attention than the other devices.

Quite recently an instrument has been devised acting upon the principle of the telephone. In this instrument a small telephonic receiver is held close to the ear. This is connected by flexible cords with a sound receiver which may be worn beneath the coat or beneath the folds of the dress, while a small storage battery is carried in the pocket. A modified and more bulky form of this apparatus has been devised in which the sound receiver is placed upon a desk or table. This instrument certainly helps some patients, and they are able to carry on a conversation, listen to lectures and music, or enjoy the theatre, public speeches, and so forth. At best, however, the device is cumbersome and possesses no very great advantages over the more simple instruments already detailed.

INDEX.

- Abortive treatment of mastoiditis, 459.
  - author's statistics of, 461.
- Abscess of auricle, 201.
  - cerebellar, 476, 586. See CEREBELLAR ABSCESS, 476.
  - diagnosis of, by aid of nystagmus, 617.
    - surgical treatment in, 586.
  - cerebral, 472, 586. See CEREBRAL ABSCESS, 472.
    - surgical treatment in, 586.
  - epidural, 583.
  - extradural, 471. See EXTRADURAL ABSCESS, 471.
- Accidents from mastoid operation, 536, 538, 540.
- Acoumeter, electric, 146.
  - Politzer's, 143.
- Acoustic papilla, 41.
- Acute infectious diseases, aural complications in, 671.
  - involvement of internal ear in, 654.
  - involvement of perceptive mechanism in, 654. See PERCEPTIVE MECHANISM, INVOLVEMENT OF, IN ACUTE INFECTIOUS DISEASES, 654.
  - inflammation of labyrinth, secondary to acute purulent otitis media, 646. See LABYRINTH, ACUTE INFLAMMATION OF, SECONDARY TO ACUTE PURULENT OTITIS MEDIA, 646.
- Adenoid growths, effect upon middle ear, 133.
  - effect upon labyrinth, 134.
  - importance of recognition in early life, 134.
  - vegetations, 709.
    - treatment of, 711.
- Adhesions in middle ear, physical signs of, 102.
  - intratympanic, evidence of, 95.
- Adhesions within the tympanum, division of, 496.
- Aids to hearing, artificial, 715.
- Ampullæ, 35, 40.
  - stimulation of, 604, 605.
    - by rotation of body around horizontal axis, 605.
- Anæmia of labyrinth, 619.
- Anæsthesia in middle-ear operations, 485. See NITROUS OXIDE.
- Anastomosis between tubal veins and turbinated plexus, 30.
- Anatomy of the ear, 3.
  - of the mastoid process, 442.
- Angioma of the auricle, 209.
- Annulus tympanicus, the, 8.
- Anomalies in position of lateral sinus, 445.
  - of antihelix, 174.
  - of antitragus, 175.
  - of helix, 174.
  - of lobule, 174.
  - of tragus, 175.
- Anterior fold, the, 22.
  - ligament of malleus, 18.
    - division of, 495.
  - pyramid, the, 27.
  - wall of the tympanum, 13.
- Antihelix, the, 5.
  - anomalies of, 174.
  - crura of, 5.
  - fossa of, 5.
- Antitragus, the, 5.
  - anomalies of, 175.
- Anton, 206.
- Antrum, the mastoid, 9, 442, 443.
  - position of, 443, 448.
- Appendages, auricular, 178, 179.
- Aquæductus cochleæ, 36.
  - Fallopii, 12.
  - vestibuli, 35.
- Arch of Corti, 41.
- Arteries of the ear, 28.
  - of the labyrinth, 44.

Artery, ascending pharyngeal, 30.
  auricularis profunda, 30.
  cochlear, 45.
  deep auricular, 30.
  descending palatine, 30.
  facial, 30.
  internal auditory, 44, 45.
  internal carotid, 13, 30.
  internal maxillary, 29.
  occipital, 29.
  posterior auricular, 29.
  pterygo-palatine, 30.
  superficial petrosal, 29.
  temporal, 29.
  tympanic, 29.
  vestibular, 45.
  vestibulo-cochlear, 45.
  Vidian, 30.
Articulation, incudo-stapedial, 17, 498.
  malleo-incudal, 17.
  stapedio-vestibular, 17.
Artificial aids to hearing, 715.
  ear-trumpet, 715.
    modifications of, 716.
  telephone, 716.
Ascending pharyngeal artery, 30.
Aspergillus of meatus, 246, 247.
Asymmetry of the ear, 173.
Atheroma of the auricle, 207.
Atrophic rhinitis, 706.
  signs of, 136.
Attolens aurem, 27.
Attrahens aurem, 27.
Audition, effect of functional nervous diseases upon, 682.
  limits of, 148.
Auditory apparatus, concerted action of, 66.
  cortical centre of, 46.
Auditory hairs, the, 39.
  hyperæsthesia, 71.
  nerve, 45.
    fatigue of, 70, 164.
    galvanic reaction of, 167.
      method of determining, 168.
    increased irritability of, to galvanic current, 160.
    loss of function of, from disease, 161.
    reaction of, after destruction of labyrinth, 65.
    reaction of, to sonorous vibrations, 65.
    torpidity of, 644.
    trunk, effect of lesions of, on perception of musical tones, 165.
Auditory nerve trunk, lesions of, galvanic reaction test for, 614, 615.
  paræsthesia, 71.
  process, the, 8.
Aural affections dependent upon chronic visceral conditions, 674.
  complications, in acute infectious disease, 671.
    in diabetes, 679.
  discharges, bacteria in, 328.
  disturbances, reflex, 688.
  fistula, congenital, 179.
  involvement, in gout and rheumatism, 679.
    in hysteria, 685.
    in leucæmia, 677.
    in metastasis, 675.
    in nephritis, 674.
    in neurasthenia, 682.
    in syphilis, 195, 631.
    in tuberculosis, 676.
  polypi, 404.
    removal of, 416, 417.
  reflexes, 67.
  specula, 83.
  speculum, improvised, 85.
  suppuration, surgical treatment of, 569.
    intracranial complications of, 569.
  synergy, 66.
Auricle, the, 4.
  abscess of, 201.
  angioma of, 209.
  atheroma of, 207.
  benign tumors of, 206.
  contusion of, 183.
  cutaneous diseases of, 187.
  cystoma of, 210.
    treatment of, 211.
  deformities of, 174.
  diseases of, 173.
  eczema of, 187.
    treatment of, 181.
  epithelioma of, 213.
  erysipelas of, 201.
  fibroma of, 206.
  function of, 50.
  gangrene of, 205.
  glands of, 23.
  hæmatoma of, 184, 202.
    treatment of, 203.
  herpes of, 193.
    treatment of, 194.
  inflammatory affections of, 200.
  intertrigo of, 187.

Auricle, lipoma of, 207.
  lupus of, 197, 198.
  malformations of, 173, 176.
  malignant tumors of, 213.
  malposition of, 176.
  ossification of, 204.
  papilloma of, 212.
  pemphigus of, 193.
  perichondritis of, 184, 200.
    treatment of, 185, 201.
  sarcoma of, 216.
  syphilis of, 195.
  wounds of, 183.
    treatment of, 184.
Auricular appendages, 178.
  artery, the posterior, 29.
Auricularis magnus nerve, the, 31.
  profunda artery, the, 30.
Auriculo-temporal nerve, the, 31.
Auscultation, the value of, 103.
Auscultatory sounds, 113.

Bacon's scarificator, 227.
Bacteriological infection of tympanum, culture of discharge in, 302.
  in intratympanic inflammation, 300, 301.
Baginsky, 59.
Ballance, 547, 554, 559, 575.
Barany test, 604, 612.
Baratoux, 196.
Barth, 145, 178.
Basilar membrane, epithelium of, 41.
  function of, 59.
Bergmann, 475, 546, 547.
Berthold, 44.
Bezold, 62, 150, 157.
Binder, 175.
Bing, 162.
Blake, 26, 100, 144, 419.
Blake's middle-ear syringe, 339.
Blood culture, value of, in sinus thrombosis, 470.
Blood supply of the ear, 28.
Boenninghaus, 580.
Boettecher, 44.
Bone conduction, augmentation of, by increased labyrinthine pressure, 161.
  cause of augmentation of, 160.
  estimation of, 151.
  value of, 150, 151.
Bony canal, the, 7, 9, 11
Bosworth, 135, 700, 704, 706, 709.
Botey, 100.
Bougie, electric, for dilatation of Eustachian tube, 373.
  Eustachian, 313, 389.
Boyer, 120.
Brenner, 167.
Brown, Gardiner, 154.
Brown-Séquard, 202.
Brunner, 202.
Bryant, 26.
Buck, 109, 212, 362.
Bürkner, 180.
Burnett, 180.

Calcific deposits in drum membrane, 385.
Caloric test, 612.
  in cases of tumor of porus acusticus, 616.
Canal, the bony, 7.
  the carotid, 13.
  the cartilaginous, 6.
  the cochlear, 36.
  the Eustachian, 13.
  the external auditory, foreign bodies in, 279. See MEATUS, EXTERNAL AUDITORY, FOREIGN BODIES IN, 279.
  the Fallopian, 12, 524.
Canalis centralis modioli, 36.
  reuniens Hensenii, 37.
  spiralis modioli, 36.
Canals, the semicircular, 35, 601.
  ampullæ of, 601.
    experiments in stimulation of, 601.
  fluid in, 605.
  functions of, 60, 601.
  graphical representation of, 603.
  horizontal system of, 602.
    determining integrity by rotation of, 608.
  position in three planes of body of, 601.
    method of illustrating for purposes of demonstration of, 601.
      position of arms in horizontal system, 602.
      position of arms in superior system, 602.
      position of hands, 603.
  posterior system of, 603.
  stimulation of horizontal system of, 605, 606, 607.
  stimulation of superior system of, 609, 610.
  superior system of, 602.
    stimulation of, by backward bending of head, 610.

Canals, stimulation of, by nystagmus, 610.
  stimulation of by rotation, 609.
Capsule, labyrinthine, rarefying osteitis of, in otosclerosis, 382.
Caries of the incus in middle-ear suppuration, 523.
Carotid canal, the, 13.
Cartilaginous meatus, the, 6.
Cassebohm, 362.
Catarrh, Eustachian, 304. See Eustachian Tube, Congestion of, 304.
  naso-pharyngeal, 713.
  tubo-tympanic, 317. See Tubo-tympanic Congestion, 317.
Catarrhal inflammation of the middle ear, acute, 327. See Otitis Media, Acute Catarrhal, 327.
Catheter, bougie, author's, for Eustachian tube, 313.
  Eustachian, form of, 107.
  Noyes' Eustachian, 124.
  Pomeroy's faucial, 125.
Catheterization, apparatus for, 109.
  dangers of, 129.
  methods of, 119–121.
  obstacles to, 122.
  of Eustachian tube, 107.
    technique of, 111.
    through opposite nostril, 123.
    use of cocaine in, 128.
    value of, as compared with Politzerization, 130.
Caudate process, 5.
Cavity, the tympanic, 12.
Cerebellar abscess, 476, 586.
  counter drainage in, 594.
  diagnosis of, 477.
    by aid of character of nystagmus, 617.
  drainage through sinus area, 594.
  evacuation of, in front of sinus, 593.
  frequency of, 476.
  pathological changes in, 476.
  prognosis of, 478.
    statistics of recoveries, 478.
  surgery of, 586.
    exploration for, 593.
      site of, 593.
    exposure of cerebellum, 593.
    puncture of cerebellum, 593.
      after-treatment, 594.
  symptomatology, 477.
Cerebellar abscess, symptomatology, increased intracranial pressure, 477.
    temperature, 477.
  treatment, 478, 593.
Cerebral abscess, 472, 586.
  decompression in, 592.
  diagnosis of, 475, 586.
  pathology of, 473.
  prognosis of, 475.
  statistics, 476.
  surgery of, 586.
    accidents in, 592.
    after-treatment, 590.
    encephaloscope in, 589.
    exploratory procedures in, 587.
    irrigation in, 589.
    technique of, 587.
  symptomatology of, 473.
  treatment of, 476, 586.
    when not localized, 592.
  use of retractors in evacuating, 588.
  usual site, 587.
  vomiting in, 473.
Cerumen, impacted, 267.
  ætiology of, 267.
  diagnosis of, 271.
  dilatation of canal from, 268.
  pathology of, 268.
  prognosis of, 272.
  symptomatology of, 269.
    reflex disturbances from, 270.
    vertigo from, 271.
  treatment of, 274.
Chatellier, 193.
Chimani, 209.
Cholesteatoma, 401.
  acute symptoms following, 402.
  development of, 423, 435.
Cholewa, 69, 231, 377, 493.
Chorda tympani nerve, the, 32.
Chronic catarrhal otitis media, 357. See Otitis Media, Chronic Catarrhal, 357.
  naso-pharyngitis, 713.
  otorrhœa, radical operation for, 546.
    use of powders in, 414.
  purulent otitis media, 397. See Otitis Media, Chronic Purulent, 397.
Chronic purulent otitis media, cerebral abscess in, 472.
  extradural abscess in, 471.
Circulatory phenomena, 68.
Cisterna lymphatica, 38.
Classification of middle-ear operations, 485.

Cleveland, 68.
Cocaine, use of, in catheterization, 128.
  in middle-ear operations, 128, 485.
Cochlea, the, 12, 35.
  function of, 57.
  result of destruction of, 66.
  the membranous, 40.
Cochlear artery, the, 45.
  canal, the, 35, 36.
  nerve, the, 45.
    decussation of, 45.
    termination of, 43.
Coil, Leiter, 460.
Color of membrana tympani, 92.
Compensation in static labyrinth, 611.
Complicating aural disease, 671.
Concerted action of auditory apparatus, 66.
Concha, the, 5.
Concussion of labyrinth, 72.
Conducting apparatus, the, 4.
  mechanism, signs of lesions in, 154.
Congenital malformations of the auricle, 173.
Congestion, tubal, 304. See EUSTACHIAN TUBE, CONGESTION OF, 304.
  tubo-tympanic, 317. See TUBO-TYMPANIC CONGESTION, 317.
Contusion of the auricle, 183.
Corradi, 66.
Corti, arch of, 41.
  membrane of, 43.
  rods of, 58.
    function of, 59.
Cortical auditory centre, the, 46.
Cough, reflex aural, 270.
Cranial fossa, middle, 446.
Crista vestibuli, 35.
Cristæ acusticæ, 40.
Croupous external otitis, 261.
Crura furcata, the, 5.
  helicis, the, 5.
Culture of discharge in bacteriological infection of the tympanum, 302.
Cunningham, 460.
Cupola, the, 36.
Cutaneous diseases of the auricle, 187.
Cutogno, 38.
Cystoma of the auricle, 210.
  treatment of, 210.

Darwinian ear, the, 174.
Deaf-mutism, ætiology of, 694.
Deaf-mutism, diagnosis of, 696
  pathology of, 695.
  prognosis of, 697.
  symptomatology of, 696.
  treatment of, 697.
Decussation of auditory nerve fibres, 47.
Deep auricular artery, the, 30.
Deformities of the nasal septum, 704.
Deiters' cells, 42.
  nucleus, 604.
Deleau, 123.
Delstanche's masseur, 389.
Dental caries, effect of, on ear, 69.
De Rossi, 189.
Descending palatine artery, the, 30.
Development of bony meatus, the, 7.
  of tympanic vault, the, 9.
Diabetes, aural complications in, 679.
Differential diagnosis, value of functional examination in, 155.
Digital examination of pharyngeal vault, 133.
Dilatation of Eustachian tube by electric bougie, 373.
Diphtheria, involvement of internal ear in, 655.
Diphtheritic external otitis, 261.
Diploic mastoid, 443.
Disarticulation of incudo-stapedial joint, 498, 504.
Discharges, aural, bacteria in, 328.
Discharge in bacteriological infection of tympanum, culture of, 302.
Diseases of the auricle, 173.
  of the external canal, 217.
  of the mastoid, 449.
  of the mastoid process, 442.
  of the middle ear, 297.
  of the nose and naso-pharynx, 698.
  of the perceptive mechanism, 597.
Division of adhesions within the tympanum, 496.
  of the anterior ligament of the malleum, 495.
Double caloric and double galvanic tests in cases of tumor of porus acusticus, 616.
Drugs, toxic effects of, upon the ear, 680.
Drum membrane, the, 21.
  calcific deposits in, 385.
  multiple incision of, 491.
  normal appearance of, 92.
  reproduction of, after removal, 513.
Ductus endolymphaticus, 38.

Duel, 373.
  electrolytic method of dilatation, 373.
Duration of sound perception as quantitative test, 145.

Ear, anatomy of, 3.
  arteries of, 28.
  asymmetry of, 173.
  blood supply of, 28.
  Darwinian, 174.
  effect of hysteria upon, 685.
    of neurasthenia upon, 682.
    of functional nervous diseases upon, 680.
  functional examination of, 142.
  internal, 34.
  involvement of, in acute infectious diseases, 671.
    in diabetes, 679.
    in gout and rheumatism, 679.
    in leucæmia, 677.
    in nephritis, 674.
    in syphilis, 631.
    in tuberculosis, 676.
  lymphatics of, 31.
  metastasis of, 675.
  muscles of, 26.
  nerves of, 31.
  physical examination of, 73.
  physiology of, 48.
  "prize-fighters," 184.
  reflex affections of, 688.
  sympathetic involvement of, 639.
  syringe, 234.
  the influence of drugs upon, 680.
  the satyr, 17.
  tone limits of, 48.
  veins of, 34.
Earache, causes of, 217, 333, 341.
  treatment of, 226, 336.
Ear-trumpet, 715.
  fan, 716.
  London hearing horn, 715.
  lorgnette, 716.
  walking-stick, 716.
Eczema of the auricle, 187.
  necrosis of auricle following, 189.
  treatment of, 188.
Eichler, 44.
Eitelberg, 164, 169.
Electric acoumeter, 145.
  bougie for dilatation of Eustachian tube, 373.
Embolism, labyrinthine, 629. See LABYRINTHINE EMBOLISM, 629.
Emphysema, following catheterization, 129.
Encephaloscope, the, 589, 590.
Epidemic cerebro-spinal meningitis, 657. See MENINGITIS, EPIDEMIC, LABYRINTHINE INFLAMMATION IN, 657.
  influenza, involvement of internal ear in, 657.
Epidural abscess, 583.
  perforation for evacuation of, 583.
  technique of operation, 583.
    after-treatment, 584.
  thrombus in lateral sinus when in floor of abscess, 585.
Epithelioma of the auricle, 213.
Epitympanic recess, the, 13.
  space, the, 13.
Erysipelas of auricle, 201.
Eustachian canal, the, 13.
  catarrh, 304. See EUSTACHIAN TUBE, CONGESTION OF, 304.
  catheter, 107.
    curve of, 108.
    faucial, 125.
    Noyes', 124.
  tube, the, 19.
    catheterization of, 107.
    congestion of, 304.
      ætiology of, 304.
      diagnosis of, 306.
        functional examination, 308.
        physical examination, 306.
      pathology of, 304.
      prognosis of, 310.
      symptomatology of, 305.
      treatment of, 311.
        astringents, 312, 314.
        bougie, 313.
        inflation, 311.
        naso-pharynx, 314.
        prophylaxis, 316.
        use of vapors, 315.
    dilatation of, by electric bougie, 377.
    effect of stenosis of, on upper tone limit, 64.
    function of muscles of, 56.
    mucous membrane of, 23.
    muscles of, 28.
    tympanic opening of, 13, 99.
    veins of, 30.
Ewald, 61.
Examination of ear, functional, 142.
  physical, 73.
    obstacles to, 95.

Examination of ear, value of auscultation in, 103.
    value of probe in, 100.
  of mouth, 132.
  of nose and pharynx, 132.
  of static labyrinth, 601.
Excision of internal jugular vein, statistics in, 578.
Excision of portion of malleus, 498.
Exostoses of external auditory meatus, 285. See MEATUS, EXTERNAL AUDITORY, EXOSTOSES OF, 285.
Exploration of cerebellum, 592, 593.
  of cerebrum, 586.
Exploratory myringotomy, 489.
External auditory meatus, absence of, 176.
    congenital occlusion of, 176.
      treatment of, 181.
    diseases of, 217.
    examination of, 88.
    function of, 50.
    fundamental note of, 51.
    malignant tumors of, 213.
  ear, the, 4.
    ligament of the malleus, 18.
    otitis, acute circumscribed, 217. See OTITIS, ACUTE CIRCUMSCRIBED EXTERNAL, 217.
    otitis, hæmorrhagic, 265.
Extradural abscess, 471.
  location of, 471.
  prognosis of, 472.
  statistics of, 472.
  symptomatology of, 471.
  treatment of, 472.
Eye, adduction of left, 605.
  adduction of right, 605.
  deviation of, 605.
  experiments of Hoyges, Von Stein, Neumann on, 605.
  motion by stimulation of semicircular ampullæ of, 604.
  nystagmus of, 605.
    apparatus for experiments in, 609.
    conscious subject in, 605.
    cerebral phase of, 606.
    direction of, 607.
    duration of, 607.
    experiments in, 604, 605, 606, 607, 608, 609.
    quick component of, 606.
    by quick motion to right, to left, 606.
    by rotation of body, 605, 606, 607.
Eye, response of muscles by stimulation of semicircular canals of, 605, 606, 607.
  vestibular component of, 606.

Facial artery, the, 30.
  nerve, the, 12.
    injury of, in intratympanic operations, 524.
    injury of, in mastoid operations, 540.
  paralysis of, as a symptom of secondary labyrinthine involvement, 647.
Fallopian canal, the, 12, 32.
Fan, ear-trumpet in shape of, 716.
Fatigue of auditory nerve, 70, 164.
Fenestra ovalis, the, 12.
    niche of, 12.
Fenestra rotunda, the, 12.
Fibroma of the auricle, 206.
Field of middle-ear operations, preparation of, 483.
Fischenisch, 211.
Fissura intertragica, the, 5.
Fissure, the Glaserian, 9.
  the Rivinian, 92.
Fistula congenita auris, 179.
Flap formation in radical operation for chronic otorrhœa, 552.
Flesch, 202.
Fluid in tympanum, signs of, 365.
Folds of the membrana tympani, 91.
Foreign bodies in the ear, 279.
Fossa, glenoid, 9.
  of the helix, 5.
  Rosenmüller's, 138.
  the jugular, 13.
  the middle cranial, 446.
Fracture of base of skull, rupture of membrana tympani in, 292.
Frank, 120.
Free exposure of dura in meningitis, 580.
Frey, 543.
Functional examination, 142, 601.
  instruments for, 148, 601.
  nervous disorders, auditory disturbances in, 680.
  technique of, 155, 601.
  value of, in differential diagnosis, 151, 601.
Fundamental note of sounding body, the, 49.
Furuncle, 217. See OTITIS, ACUTE CIRCUMSCRIBED EXTERNAL, 217.

Gad, 51, 54, 65.
Galton whistle, the, 149.
  method of using, 159.
  modification of, 156.
  physics of, 149.
  value of graduations of, 149.
Galvanic reaction of auditory nerve, 167.
  tests, determining lesions of auditory nerve trunk by, 614, 615.
  in cases of porus acustica, 616.
Ganglion, Meckel's, 32.
  otic, 31, 32.
Gangrene of auricle, 205.
Gellé, 69, 163.
General nervous diseases, effect of, upon perceptive mechanism, 666.
Geniculate ganglion, inflammation of, 194.
Gerlach, 24.
Glands of the auricle, 23.
Glaserian fissure, the, 9.
Glenoid fossa, the, 9.
Glosso-pharyngeal nerve, the, 31.
  tympanic branch of, 31.
Gout, aural complications in, 679.
Gradenigo, 14, 146, 160, 164, 165, 678.
Granulation tissue, removal of, 416.
Green, 194, 493.
Gruber, 121, 230, 265, 491, 493.
Gruening, 201, 462.
Grunert, 421.

Haberman, 206.
Hæmatoma auris, 202.
  of auricle, 184.
Hæmorrhage, labyrinthine, 626. See LABYRINTHINE HÆMORRHAGE, 626.
Hæmorrhagic external otitis, 265.
Hair cells, the, 39, 42.
Hamular process, the, 36.
Harmonics, 49.
Hartmann, 108, 157, 211, 260, 493.
Hartmann's series of tuning forks, 158.
  tenotome, 495.
Hasslauer, 300.
Haug, 207.
Head mirror, the, 80, 81.
Hearing, artificial aids to, 715.
Hearing-horn, London, 715.
Hearing, qualitative tests of, 148, 155.
  quantitative tests of, 142, 145, 155.
  value of whisper in, 144.
Helicotrema, 36.
Helix, the, 4.
  anomalies of, 174.
  spine of, 5.
Helmholtz, 18, 52.
Hensel, canal of, 37.
Herpes of auricle, 193.
  treatment, 194.
History, scheme of, 139.
Hommel, 390.
Horizontal semicircular canal, the, 12.
Hoyges, 604.
Hunt, J. Ramsey, syndrome of, 194.
"Hutchinson teeth," 632.
Hyperæmia of labyrinth, 622. See LABYRINTH, HYPERÆMIA OF, 622.
Hyperæsthesia acustica, 71.
Hypertrophic rhinitis, 700.
  signs of, 135.
Hypertrophy of third tonsil, 709.
  treatment of, 711.
Hyrtl, 492.
Hysteria, disturbance of audition in, 685.
  diagnosis of, 686.
  prognosis of, 687.
  symptomatology of, 685.
  treatment of, 687.

Ice-coil, in treatment of acute purulent otitis media, 351.
  in treatment of mastoiditis, 460.
    statistics of, 461.
  in treatment of otitis media purulenta residua, 432.
Illumination, method of, 76.
Impairment of hearing, 616.
Incision of membrana tympani, 324, 337, 350, 375, 486, 488.
    in mastoiditis, 461.
  of posterior fold, 492.
Incisures of Santorini, the, 7.
Incudo-stapedial articulation, position of, 97.
  joint, disarticulation of, 498, 504.
  ligament, the, 19.
Incus, the, 17.
  division of long process of, 498.
  frequency of caries of, in middle-ear suppuration, 523.
  ligaments of, 18.
  plastic operation for purpose of uniting to membrana tympani directly, 500.
  removal of, 505, 506.

Infection, bacteriological, in intratympanic inflammation, 300, 301.
Infectious diseases, acute, aural complications in, 671.
  diseases, influence of severity of, upon aural complications, 672.
Inflammation, intratympanic, 300.
  bacteriological infection in, 300, 301.
  of labyrinth, secondary, 635. See LABYRINTH, SECONDARY INFLAMMATION OF, 635.
  of the mastoid process, 449.
Inflammatory affections of the auricle, 200.
Inflation, methods of, 103.
Influenza, epidemic, effect of, on perceptive apparatus, 657.
Infundibulum, the, 36.
Injuries of the membrana tympani, 291.
Injury of facial nerve in mastoid operation, 540.
Inner tympanic ball, the, 12.
  plane of, 13.
Instruments for functional examination, 148.
  preparation of, for operations, 138.
Interference otoscope, 165.
Internal carotid artery, the, 13, 30.
Internal ear, the, 34.
  involvement of, in acute infectious diseases, 654. See PERCEPTIVE MECHANISM, INVOLVEMENT OF, IN ACUTE INFECTIOUS DISEASES, 654.
  involvement of, in diphtheria, 656.
  involvement of, in epidemic influenza, 657.
  involvement of, in parotiditis, 656.
  involvement of, in typhoid and typhus fever, 656.
  syphilis of, 631. See LABYRINTH, SPECIFIC INFLAMMATION OF, 631.
Internal jugular vein, the, 13.
  maxillary artery, 29.
Interossicular ligaments, the, 19.
Intertrigo of auricle, 187.
Intercranial complications of middle-ear suppuration, treatment of, 569.
  lesion, localization by tests of horizontal and superior canals, 617.
  presence of nystagmus in, 614.
  of tympanic inflammation, 463.
Intratympanic adhesions, signs of, 95.
Intratympanic folds, 25.
  ligaments, the, 17.
    anomalies in tension of, 367.
  muscles, the, 27.
  pressure, influence of, on labyrinth, 62.
Introduction of Eustachian catheter, technique of, 111.

Jacobs, 557.
Jankau, 166, 167.
Jansen, 554, 557.
Jugular fossa, the, 13.
Jugular vein, statistics following excision of, 470, 578.
Junken, 209.

Kaiser, 39.
Katz, 43.
Kessel, 125, 501, 510.
Kipp, 207, 209.
Knapp, 400, 472.
Koch, 476.
Koenig's rods, 150.
Kőrner, 445, 476, 478, 553.
Kosegarten, 395.
Kramer, 69, 121.
Kretschmann, 522, 557.
Küster, 546.

Labyrinth, acute inflammation of, secondary to acute or chronic purulent otitis media, 646.
    ætiology of, 646.
    diagnosis of, 648.
      functional examination, 649.
      physical examination, 650.
    pathology of, 646.
    prognosis of, 650.
    symptomatology of, 647.
      facial paralysis in, 648.
    treatment of, 650.
  anæmia of, 619.
    ætiology of, 619.
    diagnosis of, 620.
      functional examination, 620.
      physical examination, 620.
    prognosis of, 620.
    symptomatology of, 619.
    treatment of, 620.
  anatomy of, 34, 37.
  blood supply of, 44.
  caloric test of, 613.
  concussion of, 72.
  effect of increased tension of, on sound perception, 63.

Labyrinth, effect of middle-ear changes upon, 61.
hyperæmia of, 622.
ætiology of, 622.
diagnosis of, 623.
functional examination, 623.
physical examination, 623.
pathology of, 623.
prognosis of, 624.
symptomatology of, 623
vertigo in, 623.
treatment of, 624.
physiology of, 57.
secondary inflammation of, following chronic middle-ear inflammation, 635.
diagnosis of, 640.
functional examination of, 641.
galvanic reaction of auditory nerve, 642.
physical examination, 640.
pathology of, 635.
prognosis of, 642.
sympathetic involvement of opposite ear, 639.
symptomatology of, 6[illegible]
influence of condition of upper air passages, 638.
treatment of, 643.
air passages in, 645.
middle ear, 643.
torpidity of nerve, 644.
specific inflammation of, 631.
ætiology of, 631.
colloidal gold test in, 633.
diagnosis of, 632.
functional examination, 632.
physical examination, 632.
examimation of spinal fluid in, 632.
Noguchi test in, 632.
pathology of, 631.
prognosis of, 633.
symptomatology of, 631.
treatment of, 633.
Wassermann test in, 632.
static, 610.
absolute or partial destruction of, 614.
method of determining by producing nystagmus, 614.
compensation of, 611, 612.
dead, 611.
degree of irritability to caloric stimulation, 613.
Labyrinth, static, diseased, 610, 611.
nystagmus in, 611.
duration of, 611.
symptoms of, 611.
tests of, 611, 612.
Barany, 612.
caloric, 612.
double caloric test for determining irritability, 614.
examination of, 601.
tests for, 612.
syphilis of, 631.
the bony, 34.
the membranous, 37.
Labyrinthine capsule, rarefying osteitis of, in otosclerosis, 382.
Labyrinthine embolism and thrombosis, 629.
ætiology of, 629.
pathology of, 629.
prognosis of, 630.
symptomatology of, 629.
treatment of, 630.
hæmorrhage, 626.
ætiology of, 626.
diagnosis of, 627.
pathology of, 626.
prognosis of, 628.
symptomatology of, 627.
treatment of, 628.
salvarsan in, 633.
suppuration, 646. See LABYRINTH, ACUTE INFLAMMATION OF.
syphilis, 631.
tension, variations in, 62.
treatment of, 633.
vertigo in, 632.
Lagena, the, 38.
Lamina spiralis, 35.
membranacea, 36.
ossea, 36.
Lateral sinus, 445.
anomalies in position of, 445.
ligature of, 594.
thrombosis of, 466. See SINUS THROMBOSIS, 466.
treatment of, 571.
wounds of, 536, 538.
Leiter's coil, 229.
in acute purulent otitis media, 351.
Lenticular process, the, 17.
Letters, logographic value of, 144.
Leucæmia, aural involvement in, 677.
Levator palati muscle, the, 28.
Ligament, anterior, of the malleus, 18.

Ligament, external, of the malleus, 18.
  incudo-stapedial, 19.
  malleo-incudal, 19.
  of the incus, the posterior, 18.
  posterior, of the malleus, 18.
  stapedio-vestibular, 19.
  superior, of the malleus, 18.
Ligaments of the incus, 18.
  of the malleus, 17.
  of the stapes, 19.
  the interossicular, 19.
  the intratympanic, 17.
Ligature of lateral sinus, 594.
Light reflex, the, 91.
  sources of, 76.
Lipoma of the auricle, 207.
Lobule, the, 6.
  anomalies of, 174.
  thickening of, 204.
  tumors of, 208.
Loewenberg, 119, 218.
Logographic value of consonants, 144.
London hearing-horn, 715.
Lorgnette, ear-trumpet, 716.
Lucae, 110, 147, 153, 165, 391, 392, 502.
  pressure sound of, 391.
Lucae's method of applying passive motion to ossicular chain, 391, 392.
Ludewig, 421, 422, 523, 525.
Lumbar puncture, 581, 582, 583.
  curative value of, in meningitis, 583.
Lupus of the auricle, 197, 198.
Lustre of membrani tympani, 92.
Lymphatics of the ear, 31.

McBride, 175.
Macewen, 466, 476, 478.
Macula acustica, 39.
  cribrosa, 44.
Malformation of the auricle, 176.
Malformations of the ear, treatment of, 177.
Malignant tumors of the auricle, 213.
Malleo-incudal articulation, function of, 53; ligament, the, 19.
Malleus, the, 14.
  anterior ligament of, 18.
  division of anterior ligament, 495.
  excision of portion of, 498.
  external ligament of, 18.
  ligaments of the, 17.
  posterior ligament of, 18.
  superior ligament of, 18.
Malposition of auricle, 176.
Manubrium mallei, position of, 90.
Marian, 208.
Massage, vibratory, 391.
Mastoid antrum, 442, 443.
    position of, 443, 448.
    relation of, to intracranial structures, 444.
  condition in infancy, 447.
  determination of tenderness over, 455.
  diploic, 443.
  inflammation of (mastoiditis), 449.
    ætiology of, 449.
      influence of diathetic conditions, 459.
    diagnosis of, 455.
      sagging of canal wall, 45.
      tenderness on pressure, 455.
      variations in temperature, 452.
    pathology of, 449.
      infection of lateral sinus, 451.
      infection through squamous plate, 451.
    perforation into digastric fossa, 450, 457.
    perforation into posterior cranial fossa, 450.
    perforation through cortex, 450.
    perforation through roof of tympanum, 450.
    prognosis of, 458.
    symptomatology of, 452.
      intracranial involvement, 453.
    treatment of, 459.
      abortive measures, 459, 460.
      importance of free drainage through meatus, 459.
      local application of cold, 460.
      operation, 461, 462.
      statistics of abortive treatment, 461.
      statistics of operative treatment, 459.
      value of radiographs in, 458.
  internal surface of, 445.
  local necrosis of, 450.
  operation, 532.
    accidents in, 536, 538.
    after-treatment, 537.
    dressing after, 536.
    exposure of dura in, 538.
    facial nerve, injury to, 540.
    Frey's method of paraffin injection, 543.
    instruments for, 534.
    Mosetig-Moorhof's, 542.
    paraffin injection, 543.

- Mastoid operation, permanent opening behind the ear, 541.
    - removal of softened bone, 535.
    - technique of, 533.
    - Trautmann's, 541.
    - treatment of mastoid wound, 536.
    - variations of technique according to the age of patient, 538.
    - wounds of dura in, 538.
  - pneumatic, 442.
  - portion of temporal bone; 11.
  - process, anatomy of, 442.
    - internal surface, 445.
    - œdema over, from circumscribed external otitis, 224.
  - sclerotic, 442, 443, 450.
  - squamous suture, the, 9, 11.
    - topography of, 444.
- Maxillary artery, the internal, 29.
- Meatus, bony, 9, 11.
    - development of, 7.
  - cartilaginous, 6.
  - external auditory, epithelioma of, 213.
    - exostoses of, 285.
      - ætiology of, 285.
      - diagnosis of, 286.
      - pathology of, 285.
      - prognosis of, 287.
      - symptomatology of, 286.
      - treatment of, 288.
    - foreign bodies in, 279.
      - diagnosis of, 281.
      - pathology of, 279.
      - prognosis of, 281.
      - removal of, by posterior incision, 283.
      - symptomatology of, 280.
      - treatment of, 282.
    - sarcoma of, 216.
- Mechanism, the perceptive, 33.
  - diagnosis of diseases of, 155.
- Meckel's ganglion, 32.
- Membrana basilaris, the, 37.
    - epithelium of, 41.
    - function of, 59.
  - flaccida, the, 23.
  - limitans, the, 40.
  - reticularis, the, 43.
  - tectoria, the, 43.
  - tympani, the, 21.
    - characteristics of, 92.
    - color of, 92.
    - determination of presence of, 89.
    - folds of, 91.
    - function of, 51.
- Membrana tympani, the, incision of, 325, 486, 488.
    - lustre of, 92.
    - multiple incision of, 491.
    - physical examination of, 73.
      - landmarks in, 90.
    - pockets of, 24.
    - position of, 93.
      - in infancy, 94.
    - quadrants of, 97.
    - relaxation of, 366.
    - reproduction of, after removal, 513.
    - rupture of, 292.
      - by inflation, 130.
    - segments of, 91.
    - signs of retraction of, 94.
    - structure of, 93.
    - use of artificial drum membrane, 440.
    - wounds and injuries of, 291.
      - ætiology of, 291.
      - diagnosis of, 293.
      - pathology of, 291.
      - prognosis of, 294.
      - symptomatology of, 292.
      - treatment of, 294.
- Membrane, basilar, epithelium of, 41.
  - of Corti, 43.
  - of Reissner, 37.
  - Shrapnell's, 92.
- Membranous cochlea, the, 40.
  - labyrinth, the, 37.
- Meningitis, acute, involvement of perceptive mechanism in, 661.
    - diagnosis of, 663.
      - functional examination, 663.
    - pathology of, 661.
    - prognosis of, 664.
    - symptomatology of, 661.
    - treatment of, 664.
    - epidemic cerebro-spinal, labyrinthine inflammation in, 657.
    - diagnosis of, 659.
      - functional examination, 659.
      - physical examination, 659.
    - pathology of, 657.
    - prognosis of, 659.
    - symptomatology of, 658.
    - treatment of, 660.
- Meningitis, otitic, 463.
  - diagnosis of, 465.
    - choked disk, 465.
  - drainage at internal meatus in, 581.
  - operative procedures for relief of, 579.

Meningitis, operative procedures for relief of, evacuation of ventricular fluid, 580, 581.
    exposure and incision of dura, 580.
    lumbar puncture, 581.
      as a means of diagnosis, 582.
      as a therapeutic measure, 583.
  pressure of spinal fluid increased in, 583.
  prognosis of, 466.
  purulent, 583.
  serous meningitis, 463, 464, 465.
  symptomatology of, 464.
    choked disk, 466.
  treatment of, 466.
    internal medication, 466.
    surgical measures, 466.
  value of free exposure of dura in, 580.
Metastatic aural involvement, 675.
Methods of catheterization, 119–121.
Meyer, 712.
Microtia, 176.
  treatment of, 177.
Middle cranial fossa, 446.
  accidental opening of, 538.
Middle ear, acute catarrhal inflammation of, 327. See Otitis Media, Acute Catarrhal, 327.
  acute purulent inflammation of, 341. See Otitis Media, Acute Purulent, 341.
  chronic catarrhal inflammation of, 357. See Otitis Media, Chronic Catarrhal, 357.
  chronic purulent inflammation of, 397. See Otitis Media, Chronic Purulent, 397.
  diseases of, 297.
    bacteriological infection in, 300, 301.
    classification of, 297.
  inflammation of, intracranial complications of, 463.
    surgery of, 481.
Middle-ear operations, 481.
  adhesions, division of, 496, 497.
  anæsthesia in, 484.
  classification of, 485.
    involving the intratympanic soft parts, 485.
    involving the membrana tympani alone, 485.
    involving the ossicular chain, 486.
  instruments, 481.
  position of patient, 485.
  preparation of field of operation, 483.
Middle-ear operations, statistics of author's cases, 512, 527, 529, 530.
  suppuration, in division of adhesions in, 496.
    intracranial complications, treatment of, 564.
    radical operation for, 525.
    sinus thrombosis in, 571.
    vertigo, 382.
Miot, 500.
Mirror, 78, 81.
Mobility of membrana tympani and ossicles, determination of, 100.
Mobilization of stapes, 498.
Modiolus, the, 35.
  central canal of, 36.
  spinal canal of, 36.
Mouth, examination of, 132.
Mosetig-Moorhof, 542.
Mosetig-Moorhof's operation for closure of opening behind the ear, 542.
Mucous membrane, of the Eustachian tube, 23.
  of the tympanum, 23.
  of the tympanum, reduplications of, 23–26.
Multiple incision of membrana tympani, 491.
Mumps, aural complications in, 654.
Muscle, the levator palati, 28.
  the petro-salpingo-staphylinus, 28.
  the salpingo-pharyngeus, 28.
  the spheno-salpingo-staphylinus, 28.
  the stapedius, 28.
  the tensor palati, 28.
  the tensor tympani, 13, 27.
Muscles of the ear, 26.
  of the Eustachian tube, 28.
  of the eye, 604.
  responses of, 604.
    caused by rotation of body, 605.
    caused by stimulation of semicircular canals, 605, 606, 607.
  the intratympanic, 27.
    function of, 55.
Muscular sense, the, 61.
Musical notes, perception of, 60
Myringotomy, 486.
  exploratory, 489.
  partial, 490.

Nasal cavity, method of examining, 135.
  septum, deformities of, 704.

Naso-pharyngeal catarrh, 713.
Naso-pharyngitis, chronic, 713.
Naso-pharynx, diseases of, 698.
  examination of, 132.
Necrosis of auricle from eczema, 189.
Nephritis, aural affections in, 674.
Nerve, the auditory, 45, 47.
    distribution of, 604.
    fatigue of, 164.
    galvanic reaction of, 167.
    loss of function of, from disuse, 181.
    overstimulation of, 70.
    torpidity of, 644.
  deafness, 597.
  the chorda tympani, 32.
  the cochlear, 45.
  the vestibular, 46.
  the Vidian, 32.
Nerves of the ear, 31.
  auricularis magnus, the, 31.
  auriculo-temporal, the, 31.
  cervical plexus, the, 31.
  cochlear, 45.
  facial, 31.
  glosso-pharyngeal, the, 31.
  occipitalis minor, the, 31.
  otic ganglion, the, 31.
  petrosal, the, 32.
  pneumogastric, the, 31.
  trigeminus, the, 31.
  vestibular, 46.
  Vidian, 32.
Neurasthenia, impairment of audition in, 682.
  diagnosis of, 683.
  prognosis of, 685.
  treatment of, 685.
Neumann, 604, 605.
Niche of fenestra rotunda, 12.
  the Rivinian, 22.
Nitrous oxide, use of, 234, 260, 326, 336, 349.
Nose and naso-pharynx, method of examining, 132, 135.
  diseases of, 698.
Noyes' Eustachian catheter, 124.
Nuclei, basal, 610.
Nuel's space, 42.
Nucleus, Betcherew's, 604.
  Deiters', 604.
  dorsal, 604.
Nystagmus, apparatus for experiments in, 609.
  Barany, 612.
  conscious subject in, 605.
Nystagmus, cerebral phase of, 606.
  direction of, 607.
  duration of, 607.
  experiments in, 604, 605, 606, 607, 608, 609.
  produced by galvanic current, 615.
  produced by quick motion to right, to left, 606.
  produced by rotation of body, 605, 606, 607.
  spontaneous, 611, 613.
  in static labyrinth, 611, 614.
  vestibular component of, 606.

Obstacles to catheterization, 122.
  to otoscopy, 95.
Occipital artery, the, 29.
Okada, 400.
Oliver, 68.
Operation for excision of ossicles and curettement of the tympanum, 421.
    author's statistics of, 421.
    Grunert's statistics of, 421.
    Ludewig's statistics of, 421.
  mastoid, 532. See MASTOID OPERATION, 532.
    Stacke's, 525.
    Stacke-Schwartze's, 547.
  middle-ear, 481.
    classification of, 485. See MIDDLE-EAR OPERATIONS, 485.
  Mosetig-Moorhof's, 542.
  plastic, for uniting incus or stapes to the membrana tympani directly, 500.
  radical, for chronic otorrhœa, 546.
  Trautmann's, 541.
  upon ossicles, 498.
Opiates, use of, in otalgia, 336.
Os orbiculare, 17.
Osseous meatus, the, 7.
  development of, 7.
Ossicles, the, 14.
  development of, 14.
  leverlike action of, 53.
  operations upon, 498.
  removal of, 501.
    technique of, 502.
    in middle-ear suppuration, 516.
Ossicular chain, function of, 52.
Ossiculectomy, 501.
  after-treatment, 511, 529.
  author's statistics of after-results, 512.

Ossiculectomy, author's statistics in non-purulent otitis, 529, 530.
    in purulent otitis, 527, 530.
  carious incus, 523.
    author's statistics of, results in, 523.
  Schroeder's statistics, 527.
  technique of, in non-suppurative cases, 502.
    in suppurative cases, 516.
  value of, 521, 531.
Ossification of the auricle, 204.
Osteitis, rarefying, of the labyrinthine capsule on otosclerosis, 382.
Ostmann, 24, 58.
Othæmatoma of auricle, 202.
  treatment of, 203.
Otic ganglion, 31, 32.
Otitic meningitis, 463.
  diagnosis of, 465.
    choked disk, 465.
  prognosis of, 466.
  serous meningitis, 463, 464, 465.
  symptomatology of, 464.
    choked disk, 464.
  treatment of, 466.
    internal medication, 466.
    surgical treatment of, 466, 579.
Otitis, acute circumscribed external, 217.
    ætiology of, 217.
    diagnosis of, 221.
    enlargement of cervical glands in, 220.
    pathology of, 218.
    prognosis of, 225.
    symptomatology of, 219.
    treatment of, 226.
  acute diffuse external, 255.
    ætiology of, 255.
    diagnosis of, 256.
    pathology of, 255.
    prognosis of, 258.
    symptomatology of, 256.
    treatment of, 258.
  chronic circumscribed external, 236.
  chronic diffuse external, 238.
    ætiology of, 238.
    diagnosis of, 244.
    pathology of, 239.
    prognosis of, 249.
    symptomatology of, 242.
    treatment of, 250.
  chronic parasitic external, 239.
  externa circumscripta acuta, 217. See OTITIS, ACUTE CIRCUMSCRIBED EXTERNAL, 217.
Otitis, circumscripta symptomatica, 223.
  diffusa chronica, 238. See OTITIS, CHRONIC DIFFUSE EXTERNAL, 238.
  external, croupous and diphtheritic, 261.
    treatment of, 263.
  external hæmorrhagic, 265.
    treatment of, 266.
  media, acute catarrhal, 327.
    ætiology of, 327.
    diagnosis of, 332.
      functional examination, 334.
      physical examination, 332.
    elevation of temperature in, 330.
    pathology of, 328.
      bacteria in aural discharges, 328.
    prognosis of, 334.
      influenced by bacteriological investigation, 335.
    symptomatology of, 329.
      in adults, 329.
      in children, 330.
    treatment of, 336.
      necessity for incision, 337.
      relief of pain, 336.
      removal of discharge, 337.
      use of opiates, 336.
  media, acute purulent, 341.
    ætiology of, 341.
    diagnosis of, 346.
      functional examination, 347.
      physical examination, 346.
    pathology of, 342.
      bacteriological infection, 342.
    prognosis of, 348.
    symptomatology of, 344.
      involvement of intracranial structures, 345.
    treatment of, 349.
      abortive treatment, 350, 351.
      bloodletting, 352.
      exuberant granulation tissue, 354.
      ice-coil in treatment, 351.
      incision, 349.
      indication for use of powders, 356.
      prevention of mastoid involvement, 351.
      secondary myringotomy, 354.
      technique of incision in, 349.
  media, chronic catarrhal, 357.
  media, chronic catarrhal, hyperplastic, 379.
    ætiology of, 379.

- Otitis media, chronic catarrhal, ætiology of, influence of sex, 380.
    - simultaneous involvement of both ears, 380.
  - diagnosis of, 384.
  - functional examination, 386
    - difference in audition for voice and for sharp sounds, 386.
    - differential diagnosis from otosclerosis, 387.
    - estimation of degree of labyrinthine involvement, 387.
  - pathology of, 380.
    - changes about tympanic fenestræ, 380.
    - changes in tympanic vault, 381.
    - displacement of ossicular chain, 381.
    - involvement of labyrinth, 381.
    - otosclerosis, rarefying osteitis of the labyrinthine capsule, 382.
  - physical examination, 384.
    - appearance of membrana flaccida, 385.
    - atrophy of membrana tympani, 384.
    - calcific deposits in drum membrane, 385.
    - intratympanic adhesions, 385.
    - rotation of ossicles, 377.
  - prognosis of, 388.
  - symptomatology of, 382.
    - auditory fatigue, 383.
    - disappearance of tinnitus in late stages, 384.
    - effect on mental conditions, 383.
    - pain, 382.
    - tinnitus, 382.
    - vertigo, 382.
  - treatment of, 389.
    - internal medication, 394.
    - pilocarpine, 394.
    - potassium iodide in beginning otosclerosis, 395.
    - surgical measures, 392.
      - division of adhesions, 392.
      - exploratory myringotomy, 392.
    - vibratory massage, 391.
  - value of inflation, 389.
  - value of passive motion and massage, 389.
    - Hommel's method, 390.
    - pneumo-massage, 390.
    - pressure sound, 391.
- media, chronic catarrhal, hypertrophic, 358.
- Otitis media, chronic catarrhal, hypertrophic ætiology of, 358.
    - heredity, 359.
  - diagnosis of, 364.
    - functional examination, 368.
    - physical examination, 364.
  - pathology of, 360.
    - change to hyperplastic form, 361.
    - effect on labyrinth, 361.
    - structural changes produced, 360.
  - prognosis of, 369.
    - influence of the nose and the naso-pharynx upon, 369.
  - symptomatology of, 362.
    - impairment of audition, 362.
    - pharyngeal pain, 363.
    - tinnitus, 362.
    - vertigo, 363.
  - treatment of, 370.
    - electrolytic method, 373.
    - Eustachian tube, 371.
    - incision of membrana tympani, 375.
    - injection of fluids, 374, 377.
    - injection of medicated vapors, 377.
    - mechanical support of ossicles, 378.
    - passive motion, 378.
    - removal of effusion, 374.
    - surgical measures, 378.
    - tenotomy of tensor tympani, 376.
    - tympanum, 374.
    - upper air passages, 370.
    - value of permanent opening in membrana tympani, 379.
- media, chronic catarrhal, inflammation of labyrinth in, 617
- media, chronic purulent, 397.
  - ætiology of, 397.
    - diathetic conditions, 397.
  - diagnosis of, 405.
    - auscultatory signs, 409.
    - determination of presence or absence of ossicula, 408.
    - examination of upper and posterior quadrant, 408.
    - functional examination, 410.
    - physical examination, 405.
    - value of probe in diagnosis, 407.
    - various otoscopic appearances, 405, 406.
  - pathology of, 397.
    - caries of ossicles, 398.
    - cerebellar abscess in, 400.
    - cholesteatoma, 401.

- Otitis media, chronic purulent, pathology of, cholesteatoma, acute symptoms following, 402.
        - extension of purulent inflammation to labyrinth, 400.
        - frequent involvement of incus, 398.
        - involvement of membrana tympani, 398.
        - labyrinthine involvement, 399.
        - mastoid involvement, 400, 401.
        - meningitis in, 400.
        - result of previous catarrhal inflammation, 397.
    - prognosis of, 410.
        - factors determining probable relief of otorrhœa, 411.
        - importance of chronic otorrhœa, 411.
        - value of physical appearances in determining improvement in hearing, 411.
    - symptomatology of, 402.
        - development of aural polypi in, 404.
        - evidences of labyrinthine involvement, 405.
        - facial paralysis, 403.
        - intermittence of discharge, 403.
        - presence of granulation tissue, 404.
        - secondary infection of canal, 403.
    - treatment of, 412.
        - after removal of carious bone, 422, 423.
        - artificial protection of mucous membrane of middle ear, 419.
        - aural polypi, removal of, 416–417.
        - cholesteatoma, 424.
        - cleansing of tympanic vault, 418, 419.
        - dermoid transformation of tympanic mucous membrane, 422.
        - effect of treatment on audition, 422.
        - granulation tissue, 416.
        - importance of thorough cleansing of canal, 412.
        - importance of treatment of upper air passages, 414.
        - mucous membrane of middle ear, 413.
        - prevention of growth of aspergillus, 417, 418.
        - removal of diseased bone, 420.
- Otitis media, chronic purulent, statistics of operation, 425.
        - treatment of, use of astringents, 418.
        - valueof internal medication, 425.
        - value of powders, 414, 415.
  - media, chronic non-suppurative, inflammation of labyrinth in, 635. See LABYRINTH, 635.
  - media, chronic suppurative, inflammation of labyrinth in, 635. See LABYRINTH, 635.
  - media, intracranial complications of, 463.
  - media purulenta, treatment of meningitis in, 583.
  - media purulenta chronica, as a cause of cerebellar abscess, 476.
    - cerebral abscess, 472.
    - extradural abscess, 471.
    - sinus thrombosis, 466.
  - media purulenta residua, 426.
    - acute cases, 426.
    - ætiology of, 426.
    - diagnosis of, 428.
    - pathology of, 426.
      - development of granulation tissue, 427.
      - infection of serous discharge in canal, 427.
    - physical examination, 428.
    - prognosis of, 429.
      - danger of resulting purulent condition, 429.
    - symptomatology of, 427.
      - facial paralysis, 428.
    - treatment of, 430.
      - incision on acute cases, 431, 432.
      - irrigation, 430.
      - prevention of mastoid involvement, 431.
      - upper air passages, 430.
      - use of astringents, 430.
  - media purulenta residua, chronic cases, 432.
    - diagnosis of, 436.
      - evidences of secondary labyrinthine involvement, 437.
      - functional examination, 436.
      - physical examination, 436.
      - recognition of slight discharge, 434.
    - pathology of, 433.
    - prognosis of, 437.
      - spontaneous improvement, 438.
    - symptomatology of, 435.

- Otitis media purulenta residua, symptomatology of, development of cholesteatoma, 435.
      - facial neuralgia, 436.
      - persistent pain over mastoid, 436.
    - treatment of, 438.
      - Eustachian tube, 438.
      - hypertrophic conditions, 439.
      - importance of hygienic measures, 438.
      - internal medication with pilocarpine, 441.
      - mobilization of stapes, 440.
      - relief of tension about round window, 441.
      - relief of tension anomalies, 439.
      - stapedectomy, 440.
      - value of artificial drum membrane, 440.
  - media sclerotica, 433.
  - media serosa, 317. See TUBOTYMPANIC CONGESTION, 317.
  - media, subacute, 317. See TUBOTYMPANIC CONGESTION, 317.
- Otoliths, the, 40.
  - function of, 60.
- Otomycosis, 242.
- Otorrhœa, chronic, 546.
  - danger of infection in, 546.
  - operative procedures, 546.
    - accidents during, 561.
      - exposure of dura, 561.
      - exposure of lateral sinus, 562.
      - injury to facial nerve, 561.
      - perichondritis of auricle, 563.
    - author's method, 550.
    - Ballance's incision, 547.
    - Bergmann's method, 546.
    - dressing wound, 560.
      - avoidance of foul odor, 560.
    - Küster's method, 546.
    - lining of cavity with flaps, 552.
      - author's modification of Stacke's method, 555-557.
      - Ballance's modification, 554.
      - closure of wound, 556.
      - Jansen's modification, 554.
      - Koerner's modification, 553.
      - Panse's modification, 553.
      - permanent opening left behind ear, 557.
      - Stacke's method, 552.
      - Tiersch, 558, 559.
    - precautions to be observed, 550, 551.
- Otorrhœa, chronic, operative procedures, removal of external wall of tympanic vault, 549.
    - results following operation, 560-561.
    - secondary operation, 561.
    - Stacke's operation, 547.
    - Stacke-Schwartze operation, 547, technique of, 547.
- Otosclerosis, potassium iodide in, 395.
- Otoscope, of Siegel, 392.
  - the interference, 165.
  - the pneumatic, 101.
    - demonstration of anomalies in tension of intratympanic ligaments, 367.
- Otoscopy, obstacles to, 95.
  - technique of, 96.
- Oval window, the, 12.
- Overpointing, 611.
  - in horizontal plane, 608.
  - in vertical plane, 607, 608.
  - in lower extremities, 608.
  - experiments in, 607, 608.
  - after rotation, 608.
- Overstimulation of auditory nerve, 70.
- Overtones, 49.

- Panotitis, 646.
- Panse, 553.
- Paraffin injection for deformity following mastoid operation, 543.
- Papilla acustica, 41.
- Papilloma of the auricle, 212.
- Paracusis Willisii, 642, 663.
- Paræsthesia acustica, 71.
- Parasitic external otitis, 289.
- Parotid gland, secondary involvement of, in external otitis, 220.
- Parotiditis, involvement of internal ear in, 656.
  - simulating otitis externa, 225.
- Partial myringotomy, 490.
- Passow, 557.
- Pelvis ovalis, the, 12.
- Pemphigus of auricle, 193.
- Perceptive mechanism, diseases of, 597.
  - mechanism, effect of diseases of general nervous system on, 666.
  - mechanism, involvement of, in acute infectious diseases, 654.
    - diagnosis of, 655.
    - pathology of, 654.
    - prognosis of, 655.
    - symptomatology of, 653-655.
    - treatment of, 655

Perceptive mechanism, involvement of, in acute meningitis, 661.
    diagnosis of, functional examination, 663.
    pathology of, 661.
    prognosis of, 664.
    symptomatology of, 661.
    treatment of, 664.
  mechanism, signs of involvement of, 155.
Perichondritis of the auricle, 184, 200, 563.
  treatment of, 185.
Petro-salpingo-staphylinus muscle, the, 28.
Petro-squamous suture, the, 12.
Petrosal artery, the superficial, 29.
  nerves, the, 32.
Petrous portion of temporal bone, 11.
Pflüger, 179.
Pharyngeal sounds, 118.
  tonsil, hypertrophy of, 709.
    treatment of, 711.
  vault, digital examination of, 133.
Pharynx, examination of, 132.
Phonograph, as a test of audition, 145.
Phonometer, the, 147.
Physical examination of the ear, 73.
  sources of light for, 76.
  technique of, 83.
Physiology of ear, 48.
Pilocarpine, use of, in chronic catarrhal otitis media, 394.
  use of, in primary labyrinthine affections, 624, 628, 630, 633.
  use of, in secondary labyrinthine involvement, 644.
Pinna, the, 4.
Plexus, the tympanic, 32.
Plicotomy, 492.
Pneumatic mastoid, 442.
  speculum, use of, 101.
Pneumogastric nerve, auricular branch of, 31.
Pockets of the membrana tympani, 24.
Politzer, 6, 24, 29, 54, 63, 67, 104, 143, 265, 346, 362, 391, 395, 444, 445, 491, 495, 563, 635, 697.
Politzer's acoumeter, 143.
  bag, 104, 105.
Politzer's method for maintaining negative pressure in meatus, 391.
Politzerization, method of performing, 104.
  value of, as a diagnostic measure, 131.
Politzerization, value of, as compared with catheterization, 130.
Polyotia, 180.
Polypi, aural, 404.
  removal of, 416, 417.
  treatment of, 354, 355.
Pomeroy, 125, 154, 365, 493.
Pomeroy's faucial catheter, 125.
Position of the membrana tympani, 93.
  in infancy, 94.
Posterior, auricular artery, 29.
  fold, the, 22.
    incision of, 492.
    supernumerary, 365.
  ligament of the incus, 18.
    of the malleus, 18.
  wall of the tympanum, 13.
Powders, use of, in otorrhœa, 356, 414.
Preparation of field in middle-ear operations, 483.
Pressing, 300.
Pressure of spinal fluid, 582.
  increased in meningitis, 583.
"Prize-fighter's ear," 184.
Probe, value of, in examination, 100.
Process, the auditory, 8.
  the caudate, 5.
  the hamular, 36.
Processus cochleariformis, the, 13.
  folianus, the, 16.
  gracilis, the, 16.
  triangularis, the, 6.
Promontory, the, 12, 98.
Prussak, fibres of, 23.
  space of, 23.
Pterygo-palatine artery, the, 30.
Puncture, lumbar, 581, 582, 583.
Purulent inflammation of the middle ear, acute, 341. See OTITIS MEDIA, ACUTE PURULENT, 341.
Purulent inflammation of the middle ear, chronic, 397. See OTITIS MEDIA, CHRONIC PURULENT, 397.
Pyramid, the, 28; anterior, the, 27.

Quadrants of membrana tympani, 97.
Qualitative tests for hearing, 148.
Quantitative tests for hearing, 142.
Quincke, 463, 581.
Quincke's lumbar puncture, 581.

Radical operation for chronic otorrhœa, 546.
  statistics of, 425, 560.
Radiograph, value of, in mastoiditis, 458.

Randall, 97, 445.
Rathke, 14.
Receptive mechanism, the, 33.
Recessus ellipticus, 35.
  epitympanicus, 13.
  of Cutogno, 38.
  sphericus, 35.
Reduplication of tympanic mucous membrane, 23–26.
Reflecting mirror, the, 78.
  focal length of, 80.
  size of, 80.
Reflex aural disturbances, 67, 688.
  diagnosis of, 691.
  prognosis of, 691.
  treatment of, 691.
Reinhardt, 557.
Reissner, membrane of, 37.
Relation of mastoid to intracranial structures, 444.
Removal of incus, 506, 507.
  of malleus, 505.
  of ossicles, 501.
    technique of, 502.
      in middle-ear suppuration, 516.
  of portion of tympanic ring, 505.
  of stapes, 508.
Reproduction of membrana tympani after removal, 513.
Reticular membrane, 43.
Retraction of membrana tympani, evidences of, 94.
Retrahens aurem, 27.
Rheumatism, aural complications in, 677.
Rhinitis, atrophic, 706.
    signs of, 136, 706.
    treatment of, 707.
  hypertrophic, 700.
    signs of, 135, 701.
    treatment of, 703.
Rhinoscopy, posterior, method of, 137.
Richards, 86.
Ring, the tympanic, 8.
Rinne, 152.
Rinne's test, 152.
  variations in, with tuning forks of various pitch, 153.
Rivinian fissure, the, 92.
  notch, the, 92.
  segment, the, 22, 92.
Rods of Corti, 41.
    function of, 59.
  of König, 150.
Rohrer, 163.
Rosenmüller, fossa of, 138.
Rotating chair, 609.
Rotation, integrity of lesions of communicating fibers within brain determined by, 608.
  integrity of lesions of trunk determined by, 608.
  integrity of lesions of semicircular canals determined by, 608.
  integrity of lesions of vestibular nerve determined by, 608.
  tests, in cases of tumor of porus acusticus, 616.
Round window, the, 12.
  position of, 98.
  relief of tension at, 441.
Rüdinger, 38.
Rupture of the membrana tympani, 292.

Saccule, the, 35, 38.
Salpingitis, acute, 304. See EUSTACHIAN TUBE, CONGESTION OF, 304.
Salpingo-pharyngeus muscle, the, 28.
Salvarsan, use of, in specific inflammation of the labyrinth, 633.
Santorini, incisures of, 7.
Sappey, 24.
Sarcoma of the auricle, 216
Satyr ear, the, 174.
Scala media, the, 37, 40.
  tympani, 36.
  vestibuli, 36.
Scaphoid fossa, the, 5.
Scarificator, Bacon's, 227.
  the author's, 228.
Schimmelbusch, 218
Schmiegelow, 524.
Schroeder, 527.
Schubert, 174.
Schwabach, 154.
Schwartze, 364, 462, 493, 501.
Schwartze-Stacke operation, 546, 547.
Sclerotic mastoid, 443.
Secondary aural affections, 68.
  inflammation of labyrinth, 635.
Segment, the Rivinian, 22, 92.
Sella incudis, 17.
Semicircular canals, 35, 601.
  ampullæ of, 601.
  functions of, 60, 601.
  horizontal, 12, 602.
  position of, in three planes of body, 601.
    method of illustrating for purposes of demonstration, 601.
      position of arms in horizontal system, 602.

Semicircular canals, position of, in three planes of body, position of arms in superior system, 602.
    position of hands, 603.
  posterior system of, 602.
  superior system of, 602.
Serous meningitis, 463.
Sextar, 515.
Short process of malleus, position of, 90.
Shrapnell's membrane, appearance of, 92.
Siebenmann, 44, 63, 64, 144, 161, 251.
Siegel's otoscope, 389, 391, 392.
Signs of lesion of conducting mechanism, 154.
  of perceptive mechanism, 155.
Sinus, lateral, 445.
  anomalies in position of, 445.
Sinus thrombosis, 466, 471.
  diagnosis of, 468, 575.
    choked disk, 469.
    exploration of sinus, 571, 572.
      necessity for asepsis, 571.
    exploratory incision, 573.
    exploratory puncture, 572.
    extension of thrombosis into internal jugular vein, 574.
    general condition of patient, 469.
    importance of frequent temperature observations, 469.
    involvement of cervical lymphatics, 469.
    value of blood culture in, 470.
  prognosis of, 470.
  statistics of, 470, 578.
  symptomatology of, 467.
    constitutional symptoms, 467, 468.
    rigors, 468.
  treatment of, 470, 576.
    operative, 576.
      after-treatment, 578.
    value of blood culture in, 470.
Sinus tympanicus, the, 12.
Sound, definition of, 48.
  intensity of, 48.
  pitch of, 48.
Sounds, auscultatory, 113.
  pharyngeal, 118.
  tubal, 116.
  tympanic, 114, 116.
Special sense, a sixth, 61
Specific inflammation of labyrinth, 631.
Specific inflammation of labyrinth, salvarsan in, 633.
    treatment of, 633.
      See LABYRINTH, SPECIFIC INFLAMMATION OF, 631.
Specula, aural, 83.
Speculum, pneumatic, use of, 101.
Spheno-salpingo-staphylinus muscle, 28.
Spina tympanica anterior, 8.
  major, 8.
  minor, 8.
  posterior, 8.
Spinal fluid, cytological examination of, in meningitis, 582.
    examination of, in meningitis, 582.
    normal pressure of, 582.
  increased in otitic meningitis, 583.
Spinum supra-meatum, the, 9.
Spontaneous nystagmus, 616.
Stacke, 525, 526, 547, 549, 552.
Stacke's operation, 525.
  author's modification of, 526.
Stacke-Schwartze, 546, 547.
  operation, 547.
    author's modification of, 550–557.
    Jansen's modification of, 550, 555.
    Panse's modification of, 553.
    Koerner's modification of, 553.
    Tiersch grafting in operation, author's method, 559.
Stapedectomy, 527.
  when membrana tympani is intact, 527.
  when membrana tympani is partially destroyed, 528.
Stapedio-vestibular ligament, the, 19.
Stapedius muscle, the, 13, 28.
  division of, 496.
  function of, 55.
Stapes, the, 17.
  ligaments of, 19.
  mobilization of, 498.
  movement of, 53.
  plastic operation to unite to membrana tympani directly, 500.
  removal of, 510.
Static labyrinth, 610.
  absolute or partial destruction of, 614.
    method of determining by producing nystagmus, 614.
  compensation of, 611, 612.
  dead, 611.
  degree of irritability to caloric stimulation, 613.

Static labyrinth, diseased, 610, 611.
    nystagmus in, 611.
        duration of, 611.
    symptoms of, 611.
    tests of, 611, 612.
  Barany, 612.
    caloric, 612.
  double caloric test for determining irritability of, 614.
  examination of, 601.
  tests for, 612.
Steinbruegge, 160.
Stetter, 174.
Strychnine, value of, 395.
Sulcus laminæ spiralis, 36.
  tympanicus, 8.
Superficial petrosal artery, the, 29.
  temporal artery, the, 29.
Superior semicircular canal, rotation of, 609.
  nystagmus in, 609.
Suppuration, aural, surgical treatment of intracranial complications of, 569.
Suppuration of middle ear, acute, 341. See OTITIS MEDIA, ACUTE PURULENT, 341.
  chronic, 397. See OTITIS MEDIA, CHRONIC PURULENT, 397.
Suppurative labyrinthitis, Neumann operation for, 651.
Suppurative otitis media, cerebellar abscess in, 476.
    cerebral abscess in, 472.
    extradural abscess in, 471.
Surgical treatment of intracranial complications of aural suppuration, 569.
Suture, the mastoid squamous, 11.
  the petro-squamous, 12.
Sympathetic action of auditory apparatus, 160, 170.
  aural disturbances, 66.
  inflammation of labyrinth, 621.
Symptoms, of diseased static labyrinth, 611.
Syphilis of auricle, 195.
  of labyrinth, 631. See LABYRINTH, SPECIFIC INFLAMMATION OF, 631.
Syringing the ear, 614.
  as test for dead or diseased labyrinth, 614.
Szenes, 175.

Taylor, 196.
Technique of functional examination, 151.
  of physical examination, 83.
Telephone, as artificial aid to hearing, 714.
Temperature in cerebral abscess, 474.
  in sinus thrombosis, 468.
Temporal bone, 7, 8.
  development of, 7.
  petro-mastoid portion, 11.
  squamous portion, 9.
Tenotomy of stapedius muscle, 496.
  of tensor-tympani muscle, 376, 492.
Tensor palati muscle, 28.
  tympani muscle, 13, 27.
    function of, 55.
  tenotomy of, 376, 492.
Tests, Bing's, 162.
  Eitelberg's, 164.
  Gellé's, 163.
  Gradenigo's, 164.
  of hearing, method of conducting, 147.
    qualitative, 148.
      value of continuous series of musical notes in, 150.
    quantitative, 142, 145.
      value of phonograph, 145.
      value of whisper, 144.
  Rinne's, 152.
  Schwabach's, 154.
  Weber's, 151.
Teutleuben, 24.
Thickening of the lobule, 204.
Tiersch grafting in radical operation for chronic otorrhœa, 558, 559.
Third tonsil, hypertrophy of, 709.
    treatment of, 711.
Thrombosis, labyrinthine, 629. See LABYRINTHINE EMBOLISM AND THROMBOSIS, 629.
  of lateral sinus, 466, 571. See SINUS THROMBOSIS, 466, 571.
    treatment of, 571.
Tone limits of audition, 48.
Tonsil, pharyngeal, hypertrophy of, 709.
  treatment of, 711.
Tonsils, faucial, 371, 414.
Topography of mastoid, 444.
  of tympanum, 97.
Toynbee, 644.
Tragus, the, 5.
  anomalies of, 175.
Trautmann's operation for closure of opening behind the ear, 541.

Treatment of congenital occlusion of external auditory meatus, 181.
  of intracranial complications of middle-ear suppuration, 569.
  of malformations of the ear, 177.
  of upper air passages in secondary inflammation of labyrinth, 645.
Triquet, 121.
Troeltsch, pocket of, 347.
Trumpet, ear, 715.
Tubal catarrh, 304.
  congestion, 304.
  sounds, 116.
Tube, the Eustachian, 19.
  congestion of, 304. See EUSTACHIAN TUBE, CONGESTION OF, 304.
  muscles of, 28, 55.
Tuberculosis, aural involvement in, 676.
Tuberculum acusticum, 46.
Tubo-tympanic catarrh, 317. See TUBO-TYMPANIC CONGESTION, 317.
Tubo-tympanic congestion, 317.
  ætiology of, 317.
  diagnosis of, 319.
    functional examination, 322.
    physical examination, 319.
      evidences of fluid in tympanum, 320, 321.
  pathology of, 317.
  prognosis of, 322.
  symptomatology of, 318.
  treatment of, 323.
    evacuation of effusion by incision, 325.
    evacuation of effusion by inflation, 324.
    internal remedies, 326.
    removal of adenoid growths, 316.
    removal of faucial tonsils, 316.
Tubo-tympanitis, 317. See TUBO-TYMPANIC CONGESTION, 317.
Tumor, of the cerebello-pontine angle, 615.
    caloric test in, 616.
    diagnosis by tests of the eighth nerve, 615.
  of the eighth nerve in the porus acusticus internus, 615.
    galvanic test in, 616.
    rotation tests in, 616.
    use of X-ray plates, 616.
Tumors of the auricle, benign, 206.
  malignant, 213.
Tuning forks, Hartmann's, 158.
  method of using, 158.
Tympanic artery, the, 29.
  bruit, the normal, 114.
  cavity, the, 12.
    inflammation of, intracranial complications of, 463.
  membrane, 21.
    reproduction of, after removal, 513.
  muscles, function of, 55.
  opening of Eustachian tube, 13, 99.
  plexus, 32.
  ring, 8.
    removal of portion of, 509.
  sounds, 114, 116.
  spine, 8.
    the anterior, 8.
    the posterior, 8.
  vault, 13.
    development of, 14.
    formation of, 9.
Tympanic inflammation, intracranial complications of, 463.
Tympanum, floor of the, 13.
    dehiscences in, 13.
  inflation of, 102.
  topography of, 97.
Typhoid fever, involvement of internal ear in, 656.
Typhus fever, involvement of internal ear in, 656.

Umbo, the, 91.
Upper air passages, treatment of, in secondary inflammation of labyrinth, 645.
  tone limit, effect of middle-ear changes upon, 368.
  tone limit, lowering of, by middle-ear conditions, 161.
Urbantschitsch, 14, 66, 69, 71, 109, 145, 159, 169, 179, 218.
Utricle, the, 35, 38.

Vagus, auricular branch of, 31.
Valsalva's method of inflation, 161, 430.
Value of strychnine, 395.
  of powders in otorrhœa, 356, 414.
Vaporizer, author's, middle-ear, 315.
Vault of the tympanum, the, 13.
  development of, 14.
Vegetations, adenoid, 709.
  treatment of, 711.
Vein, the internal jugular, 13.

Veins of the ear, anastomosis of, 30.
  of the Eustachian tube, 30.
  of the labyrinth, 44.
Vertigo following inflation of tympanum, 130.
  from impacted cerumen, 271.
  in chronic hyperplastic catarrhal otitis media, 382.
  in chronic hypertrophic catarrhal otitis media, 363.
  in tubo-tympanic congestion, 319.
  labyrinthine, 601.
  middle ear, 382.
  sudden appearance of in labyrinthine syphilis, 632.
Vestibular stimulation elicited by muscular movements, 604.
Vibratory massage, 391.
Vidian artery, the, 30.
  nerve, the, 32.
Vomiting in cerebral abscess, 473.
Von Stein, 605.

Wagenhaüser, 174, 194.
Walb, 381.
Walking-stick ear trumpet, 698.
Weber, 154, 158.
Weber, F. E., 492.
Weber-Liel, 69, 376, 377, 493.
Weber's test, 151.
Weil, 202.
Wharton Jones, 69.
Whisper, as test for hearing, 144.
Whistle, the Galton, 149.
Whiting's encephaloscope, 589, 590.
Wilde's incision, 352, 432, 461.
Window, the oval, 12.
  the round, 12.
Wolff, 121.
Wounds of the auricle, 183.
  of the membrana tympani, 291.
Wreden, 498.

X-ray plates, use in cases of tumor of porus acustics, 616.

Yearsley, 710.

Zona pectinata, 41.
  perforata, 41.
  tecta, 41.
Zücker, 195.
Zuckerkandl, 26, 30.

LANE MEDICAL LIBRARY

To avoid fine, this book should be returned on
or before the date last stamped below.

OCT 6 1921
NOV 15 1921
JUL 17 1922
SEP 9 1922
OCT 26 '23
DEC 13 '24
APR 15 '27
MAR 29 28
AUG 29 28
MAR 14 1929
MAR 14 1929

R121 Dench, E.B. 47844
D39 Diseases of the ear
1919 47844

NAME	DATE DUE
F.E. Blaisdell Jr.	OCT 6 1921
J.A. Bacher	NOV 15 1921
Dr. Takahashi	JUL 17 1922
Dr. Bacher	SEP 9 1922
Roy E. Nelson	OCT 26 '23
Barlow Med. Lib.	DEC 13 '24
Hal Coates	Mar 11
P.J. Miller	APR 12
G.J. Dewall R.F.	MAR
Paul T. Pace.	AUG
S.V. Christensen	M
Prof. Wishler	